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MODERN UROLOGY

IN ORIGINAL CONTRIBUTIONS BY AMERICAN AUTHORS

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VOLUME II

DISEASES OF THE BLADDER—DISEASES OF THE URETER
—DISEASES OF THE KIDNEY

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SECTION I.

THE BLADDER.

CHAPTER I.

ANATOMY AND PHYSIOLOGY OF THE BLADDER.

By HERMAN L. KRETSCHMER, M.D.

ANATOMY OF THE BLADDER.

The urinary bladder is a mucomuscular organ, serving as the receptacle for the urine which it receives from the kidneys through the ureters, and which it discharges at more or less regular intervals through the urethra.

The capacity of the bladder is variable, the average capacity being usually stated to be between 500 and 600 c.c. The maximum capacity is attained at about the age of twenty years. The statement that the female bladder has a larger capacity than the male bladder (Disse) is open to question, it being generally believed that the male bladder is larger than the female bladder. In exceptional cases the bladder may contain upward of 1 or 2 liters of urine, but these must be considered as cases of overdistention, and belonging to the pathological rather than the physiological condition.

The shape of the bladder varies with age and sex, as well as with the condition of the organs in the pelvis and the degree of distention. In infants the bladder is pyriform in shape, due to the absence of a base, which is formed later, while in adults it is oval or elliptical. According to Voelcker and Lichtenberg the partially filled bladder is more or less triangular, with the base upward, the apex of the triangle being at the vesical neck. In men suffering from prostatic hypertrophy the base of the bladder becomes broader, a fact clearly demonstrated by cystography.

When the bladder is full it is spherical or egg-shaped. It expands chiefly in an upward direction, and also to a certain degree laterally toward the wall of the bony pelvis and posteriorly toward the rectum. According to Dixon, when the bladder is empty and contracted it forms a flattened inverted tetrahedron. A median section of the

emptied and contracted bladder shows it to be Y-shaped, the stem of the Y being the urethra and the two limbs being formed by the bladder. According to Symington the anterior limb is the longer and is directed upward and forward, while the posterior or shorter limb passes backward and upward (Fig. 1).

In the newborn and in early life the bladder is an abdominal organ. The internal urethral orifice lies on a level with the upper margin of the symphysis pubis. According to Disse the internal urethral orifice sinks rapidly after birth to the beginning of the fourth year, and then sinks more slowly from the fourth to the ninth year. From this time to puberty the bladder appears to remain stationary, only again to begin to sink down farther between the fourteenth and twentieth years. At the age of twenty-one years the bladder has reached its final resting place. During the process of descent into the pelvis the posterior wall of the bladder becomes elongated, resulting in the formation of the base of the bladder, which ultimately comes to lie in the cavity of the pelvis.

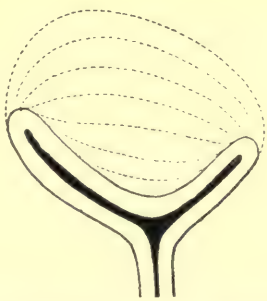

FIG. 1.—Modifications of form of the bladder during distention. (Poirier and Charpy.)

The space occupied by the bladder during its abdominal habitat has been called the Blasenspaltraum by Disse (the Blasenspaltraum is to be differentiated from the cavum Retzii prevesicale, which lies above the bladder between the abdominal muscles and the fascia endoabdominalis—Bardeleben), and according to him extends from the apex of the bladder to the middle of the symphysis; laterally it extends as far as the anterior wall of the bladder.

As the bladder sinks into the pelvis the Blasenspaltraum becomes more and more into its own, and it is then filled with a loose fat-free connective tissue. This cavity extends from the semilunar fold of Douglas to the apex of the bladder and laterally as far as the umbilical arteries. This is the preperitoneal space of Retzius (Disse).

In the adult male the bladder when contracted is situated within the pelvic cavity. The bladder together with the prostate occupies the anterior half of the pelvis. The height of the anterior wall depends upon the degree of distention. It is not covered by peri-

toneum. Part of the anterior wall lies behind the symphysis and part above it. This part of the bladder being free from peritoneal covering makes it accessible to surgical intervention. The anterior wall of the bladder is covered by a layer of fatty areolar tissue known as the prevesical pad of fat. The posterior wall is covered by peritoneum which extends from the apex down to the upper part of the seminal vesicles, partially covering the ductus deferentes. Below the peritoneum is the fixed part or base of the bladder, which is in relation to the seminal

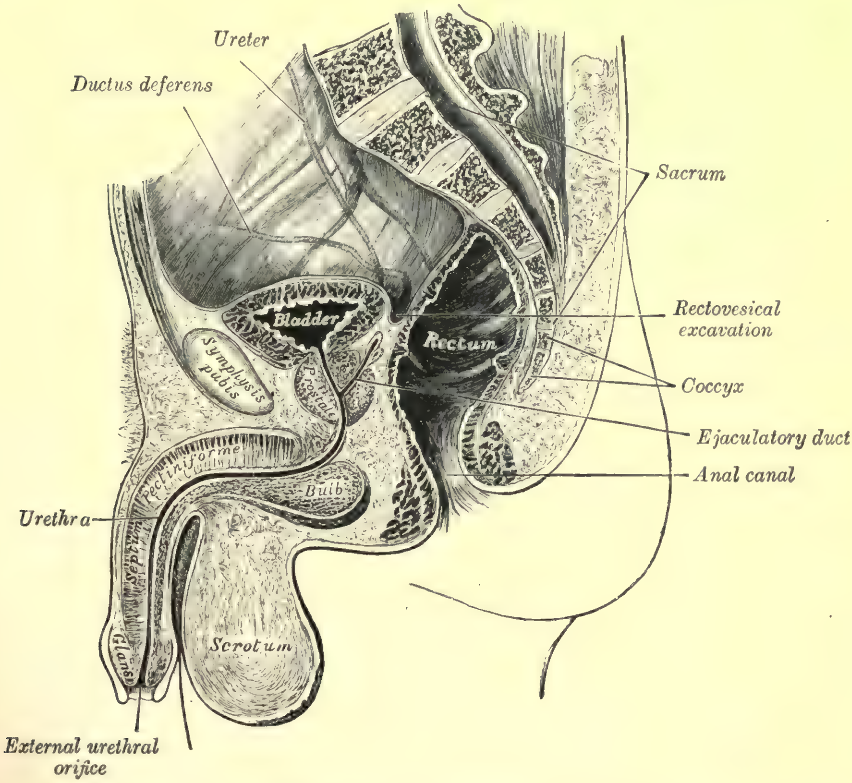

FIG. 2.—Median sagittal section of male pelvis. (Gray.)

vesicles and part of the prostate. This fixed part depends upon the rectum for its relationship to the upper part of the posterior wall. When this part is carried forward and upward by the rectum it forms a right angle with the upper part of the posterior wall, so that the base of the bladder looks upward and forward. On the other hand, when the rectum is empty the base becomes more horizontal. The base of the bladder is not covered by peritoneum.

In the adult female the bladder occupies a lower position in the pelvis than does the male bladder. This is due to the absence of the

prostate. A sagittal section through the bladder and urethra is Y-shaped, the urethra forming the stem of the Y. The anterior wall of the bladder is free from peritoneum and lies behind the symphysis. The base of the bladder is in contact with the anterior vaginal wall and the anterior surface of the cervix uteri. When contracted the peritoneum covers the upper surface of the bladder. The body of the uterus rests against the peritoneal surface of the bladder. The peritoneum leaves the bladder and is reflected over the uterus, forming the *vesico-uterine* cavity (Fig. 3).

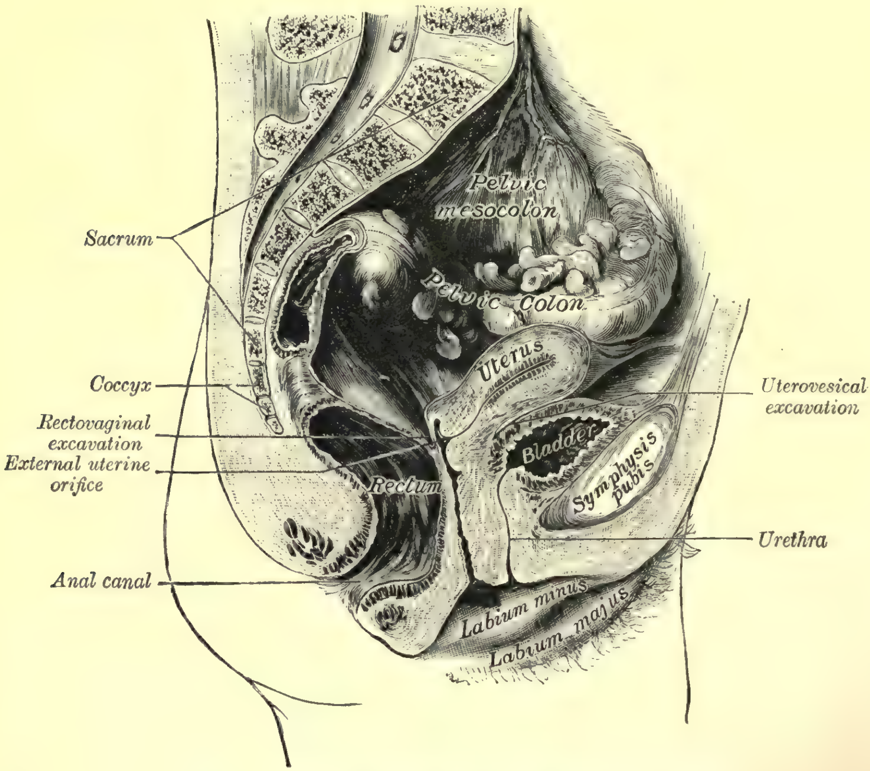

FIG. 3.—Median sagittal section of female pelvis. (Gray.)

The relations of the peritoneum to the bladder are dependent upon the condition of the bladder as well as the condition of the surrounding organs. During the latter stages of pregnancy the uterus rises out of the pelvis, drawing the peritoneum upward with it so that a large part of the posterior surface of the bladder is free from peritoneum.

The anterior surface of the bladder is not covered by peritoneum. This allows the bladder to be opened without entering the peritoneal cavity. Occasionally the peritoneum is attached farther down on

the bladder, so that the peritoneal cavity is entered when suprapubic cystotomy is performed. The base of the bladder is free from peritoneal covering.

On the lateral surfaces the peritoneum passes downward, being reflected at a point corresponding to the white line. These reflections of the peritoneum have been called the lateral false ligaments. When the bladder is distended this fold of the peritoneum is carried upward, and it may reach the level of the ductus deferentes and the obliterated umbilical artery. When the bladder is empty the peritoneum is carried down as far as the lower border of the bladder, lying in a depression known as the paravesical fossa.

On the posterior surface the peritoneum extends down as far as the upper part of the seminal vesicles and ducts, from which it is reflected onto the rectum, forming the rectovesical fold; the fossa produced thereby is called the rectovesical pouch. In women the peritoneum from the posterior surface of the bladder is reflected onto the anterior surface of the uterus.

The bladder wall is composed of four coats: a serous coat, a fibrous coat, a muscular coat, and a mucous coat.

The serous coat is formed by the peritoneum and only incompletely covers the bladder.

The fibrous coat is strongest over the inferior surface, where it receives reflections from the pelvic fascia; toward the apex and beneath the peritoneum it is less definite and often intermingled with adipose tissue. In the male this layer fuses with the fibrous tissue covering the seminal vesicles and ducts and in the female it blends with the anterior vaginal wall (Piersol).

The muscular coat is composed of unstriped muscle. This coat consists of three layers: a longitudinal or external, a middle or circular, and an inner longitudinal layer (Figs. 4, 5, and 6).

The external longitudinal layer is especially well developed on the anterior and posterior surfaces. It consists of well-defined, easily separated bundles which have their origin in the prostate in males and in the urethra in females. This layer is connected with the pubes by the m. pubovesicalis, and is connected to the rectum by the m. rectovesicalis. Some of the fibers of this layer blend with the fibers of the circular layer. A few fibers pass onto the urachus. This layer has been called the m. detrusor.

The circular layer is thicker and more uniform than the longitudinal layer. In the male this layer begins at the upper margin of the prostate behind and a few millimeters above the internal urethral orifice in front. The defect in the posterior wall of the bladder is filled by the prostate (Disse). In females this layer begins above a point connecting the two ureteral orifices.

The inner layer is formed by the loosely arranged muscle bundles in the submucosa. At the internal urethral orifice the muscle bundles are thicker and are more closely set, forming the internal vesical

sphincter. According to Disse the internal sphincter consists of two parts; one he terms the vesical part and the other the urethral part.

Kalischer calls this the m. sphincter urethræ trigonalis, and states that it consists of two parts. The posterior part is situated in the trigonum and the anterior part in the anterior wall of the urethra. The direction taken by this muscle therefore is from above downward and forward.

The submucosa is composed of fibrous tissue and elastic fibers which support the vessels and nerves. It is continuous above with the mucosa and below it blends with the fibrous tissue between the muscle bundles. The submucosa is absent over the trigone.

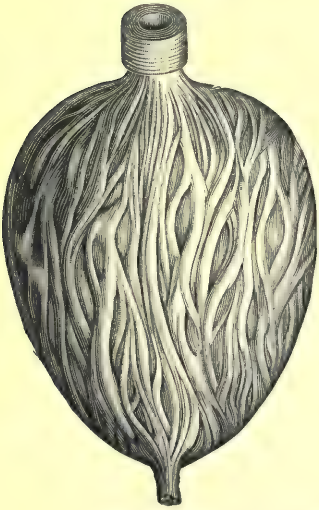

FIG. 4.—Fibers of the external longitudinal layer. Poirier and Charpy.)

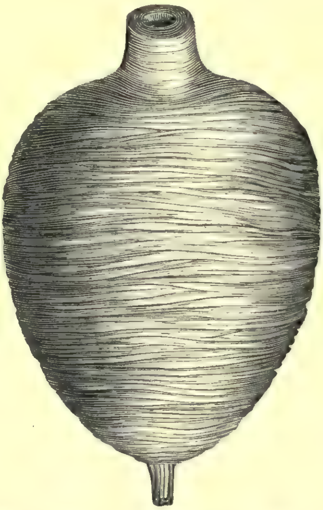

FIG. 5.—Fibers of the middle or circular layer. (Poirier and Charpy.)

FIG. 6.—Fibers of the internal longitudinal layer. (Poirier and Charpy.)

The mucous coat is smooth and glistening and of a pink color. The mucous membrane of the bladder is continuous with that of the ureters and the urethra. When the bladder is contracted the mucosa is thrown into ridges or folds, which become completely effaced as the bladder is distended. The mucosa being loosely attached to the submucosa allows of this effacement of its folds. The fixed portion of the mucosa is found over the trigone where it is attached directly to the muscularis. Here the mucosa is smooth when the bladder is empty and contracted.

This coat is lined with transitional epithelial cells, which may be said to be composed of three different types of cells: (1) The upper layer consists of large flat cells often containing several nuclei. According to Dogiel the protoplasm of these cells shows a peculiar staining reaction, the upper or superficial part of the cell staining less deeply

than the basal part. Dogiel believes these cells have a mucus-secreting function, a view shared by Lendorf, but disputed by Eggling. (2) The middle layer of cells are usually club-shaped. (3) The basal layers are more or less columnar. (Fig. 7.) Lendorf believes that the epithelium does not consist of many layers, but only of two layers.

Whether the presence of lymphatic tissue in the bladder is to be looked upon as normal or pathological is still an open question. Stoerck, Chiari, Przewoski and others look upon the presence of lymph nodules as pathological. Aschoff, Weichselbaum and others believe that under certain conditions lymph follicles may be present normally.

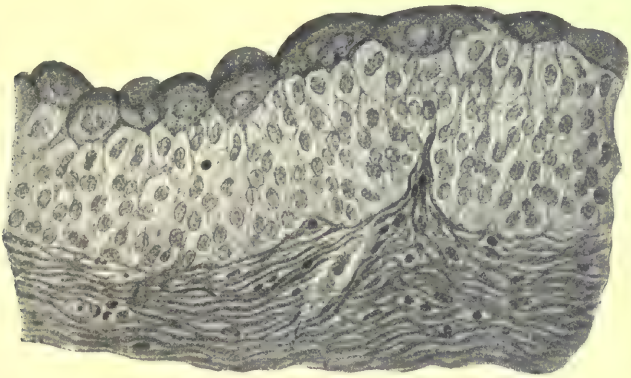

FIG. 7.—Vertical section of the vesical mucosa. (Frisch and Zuckerkandl.)

Glandular structures have been seen by Tourneaux and Hartman, Rauber-Kopsch and Zuckerkandl. Lendorf has described glandular structures around the internal urethral orifi e and in the fundus. The cell nests of Brunn cannot be considered as normal constituents of the bladder.

The ligaments of the bladder are usually described as true and false. The term false ligaments has been applied to the peritoneal reflections. Owing to the changes in the size and shape of the bladder it is apparent that the false ligaments have little if anything to do with the real bladder support.

The ligamentum umbilicale medium is formed by the urachus, the remnant of the allantois. It passes from the apex of the bladder upward to the umbilicus, running parallel to the linea alba. It has the same structure as the bladder. The ligamenti umbilicali lateralia, like the medium ligament, are the remnants of fetal life. They are formed by the obliterated hypogastric arteries which in fetal life had a branch running in the umbilical cord. They pass from the sides of the bladder upward, with their convexity toward the median line, gradually reaching the midline, where they join with the medium ligament and are fused into one cord which is inserted into the umbilicus.

The peritoneum as it passes over the urachus is raised by it. This has been termed the plicæ umbilicale medium and lies behind the linea alba. The obliterated hypogastric arteries also are covered by peritoneum, which is more or less elevated. These have been called the plicæ umbilicale lateralia.

The true ligaments of the bladder are usually given as four (if the urachus is included, which is done by some, there are five), two puboprostatic or pubovesical and two lateral. They all take their origin from the pelvic fascia. The part of the pelvic fascia that especially aids in the fixation of the bladder is a thick white glistening band that runs from the symphysis to the spine of the ischium. This band is known as the arcus tendineus. The anterior ligaments (the puboprostatic ligaments) are reflections of the pelvic fascia. They pass from the symphysis pubis backward to blend with the prostate and base of the bladder. In the female these fibers pass directly from the symphysis to the bladder (pubovesical).

The two lateral ligaments pass from the arcus tendineus toward and are attached to the lateral surfaces of the bladder. The pubovesical ligaments contain muscle fibers that pass from the symphysis pubis to the bladder, and are known as the m. pubovesicalis. Posteriorly a few muscle fibers pass backward from the bladder to the anterior wall of the rectum, and these are known as the m. rectovesicalis.

THE INTERIOR OF THE BLADDER.

When the bladder is empty the mucosa is thrown into folds which disappear as the bladder is distended. The one part of the bladder which is an exception to this is the trigonum, which is always smooth. This is due to the absence of the submucosa; in the area of the trigonum the mucosa is attached directly to the muscle layers. The mucosa is glistening and of a pink color.

The trigonum is triangular in shape, with the apex of the triangle directed toward the urethra. The base of the triangle is formed by a line connecting the two ureteral orifices. At the base the trigonum measures $2\frac{1}{2}$ cm. x 3 cm. Between the ureteral orifices can be seen a distinct ridge, with the convexity forward. This is called the interureteric ligament, or Torus uretericus (Waldeyer). That part of the Torus uretericus which lies beyond the ureteral orifices is called the plica ureterica. The interureteric ridge is not always well defined, so that at times the center may be absent. The sides of the trigone are slightly concave, with the concavity looking outward.

The ureteral orifices are not situated at the extreme ends of the Torus uretericus, but slightly mesially from the ends. The ureteral orifices are variable in shape; most frequently they are slit-like; often they are round, oval, crescentic, or punctate. The part of the bladder behind the trigonum is called the fossa retro-ureterica, or bas fond, of the French.

The internal urethral orifice is situated at the apex of the trigonum and is crescentic in outline, with the convexity looking upward. The mucosa around the orifice is surrounded by small radiating folds. At the base or posterior surface is a small elevation of mucosa called the uvula vesicæ, which may pass forward into the urethra, as the crista urethralis, as far as the prostatic urethra.

For descriptive purposes the bladder may be said to have an anterior and a posterior surface, an apex, body and base, and two lateral surfaces.

Blood Supply.—The bladder receives its blood supply chiefly through the superior and inferior vesical arteries, which are branches of the anterior division of the internal iliac. Accessory small twigs are also derived from the middle hemorrhoidal and the obturator. In the female additional branches for the bladder are derived from the uterine and vaginal arteries.

The vessels surround the bladder more or less like a network from which branches are given off which penetrate the muscular layer. Further ramifications result in the formation of plexuses in the submucosa from which the mucous membrane is supplied.

The veins do not accompany the arteries but form a submucous plexus that drains the mucous membrane and empties into the muscular plexus which in turn is received by an external subperitoneal plexus (Piersol). According to Fenwick the veins can be divided into three groups: submucous, muscular, and peritoneal. From the subperitoneal plexus the blood is conveyed into the large vesical plexus which lies at the side of the bladder. The vesical plexuses drain into the internal iliac veins.

Bacharach has recently shown by injection specimens that the great majority of the vessels of the bladder mucous membrane visible in the cystoscope are veins, not arteries.

Nerves.—According to Disse, nerves of the bladder come from the plexus vesicalis. This receives nerves from two sources: from the plexus hypogastricus, which is a combination of the plexus aorticus abdominalis, and also from the cerebrospinal plexus sacralis. The latter come from the upper sacral nerves, and they are identical with the so-called nervi erigentes.

Lymphatics.—The lymphatics of the bladder begin in the mucosa, from which they pass on through the muscularis to the outside of the bladder. They are connected with the lymphatics of the urethra (Sappey), and, according to Teichman and others, the lymphatics of the ureter communicate with the lymphatics of the bladder and kidney.

Formerly the mucosa was described as being free from lymphatics, a point now much in dispute; lymphatics in the mucosa have been demonstrated by George and Elizabeth Hoggan, Lendorf, Albarran and others.

The lymphatics from the anterior surface pass to glands along the

external iliac; those of the upper part of the bladder pass to the external iliac and to the hypogastric glands, while those of the lower part of the posterior wall pass alongside the rectum to the sacral ganglia lying at the bifurcation of the aorta (Walker).

PHYSIOLOGY OF THE BLADDER.

According to Frankl-Hochwart the physiological act of urination may be considered under the following three headings:

1. Several times during the day a desire to urinate arises. This desire gradually becomes more and more marked, finally becoming *imperative,* which is restrained by the employment of accessory muscles. When response to this desire takes place the self-imposed resistance is removed and urine flows out in a strong stream. Gradually the stream becomes weaker, and the last few drops may be expelled by aid of the abdominal muscles. This imperative urination is not the rule.

2. Usually relief is sought when a moderate desire is present. When only a moderate desire is present, one may be obliged to wait for a few seconds, which, according to Frankl-Hochwart, may be spoken of as a physiological retardation.

3. The third form of urination is not associated with urinary desire. Prior to attending a theater or a meeting where there may be no opportunity to void, one may often while thinking of this situation experience a slight desire. If this be responded to it requires waiting before the stream starts, and when it does start the amount is often small and the stream weak. Similar psychic impulses are experienced by others, who must void when passing toilets or when seeing others void.

Mechanism of Bladder Closure.—Much discussion has arisen in the past as to the role played by the internal sphincter in maintaining bladder closure. Finger, Guyon and others maintained that the internal sphincter was weak and incapable of maintaining the closure. They believed that as the amount of fluid increased the intravesical pressure increases, finally overcoming the resistance of the internal sphincter, so that the latter yields and the fluid passes into the prostatic part of the urethra. After this the urine collects not only in the bladder, but in the prostatic part of the urethra, which has become a part of it, and it assumes more and more a pear shape. The prostatic part of the urethra formed a bladder neck. That it does so Finger attempted to show by the fact that when the bladder is full the urethra is considerably shorter than when it is empty. This he attempted to prove by measuring the length of the urethra when the bladder was empty and when it was full.

These views have always been combated by many. The first attempts to disprove Finger's theory in a graphic form were made by Zeissl and Holzknecht. They filled the bladders of cadavers with

mercury and then took x-ray pictures which showed an absence of funnel formation at the vesical neck. Recent roentgenological studies have proved the correctness of the latter views, namely, that the internal sphincter is capable of maintaining bladder closure (Leedham-Green, Voelcker and Lichtenberg, Barringer and MacKee, Uhle and others), and that when the bladder is fully distended no pear-shaped neck can be demonstrated.

Rehfisch quotes the following interesting experiment as evidence that the internal sphincter may be inhibited or set into contraction directly by voluntary impulses. He passed a rigid catheter into the bladder and fully distended it with fluid. He then withdrew the catheter until its eye lay just outside the bladder in the posterior urethra; the flow of fluid from the bladder stopped at once. The patient was requested to void. This he did, and as there was considerable distention of the bladder the urine came away with considerable force, not only through the instrument but also alongside of it. The man was then told to stop micturating and the stream stopped at once. All the time this was going on the eye of the catheter was lying in the prostatic urethra, and the experiment clearly showed that the internal sphincter is the chief agent in closing the bladder, even though it be greatly distended.

The Act of Micturition.—The act of micturition is performed by a relaxation of the sphincter and a contraction of the detrusor. There have been two theories advanced to explain this act:

1. After the bladder has been distended to a certain degree, contractions are set up which force a few drops of urine into the sensitive posterior urethra from which the reflex is started. As evidence corroborating this theory the following facts were submitted. The application of strong chemicals into the prostatic urethra, instrumentation, and the presence of polyps and foreign bodies all produced an intense desire to urinate. Injection of cocain into the prostatic urethra may cause retention of urine when the bladder is fully distended (Walker).

Various facts have been presented to show the fallacy of this theory, namely, the large number of individuals whose prostatic urethras do not respond to stimulation of any kind, the fact that women have no prostatic urethra, and third, Walker has shown that the prostatic urethra may be completely removed in performing prostatectomy, and yet the act of urination is not interfered with.

According to the second theory, micturition is called forth by distention of the bladder, which stimulates the sensory nerves of the bladder. Zuckerkandl and Frankl-Hochwart have shown that in normal individuals a slight desire to urinate is present when 100 c.c. to 500 c.c. of fluid are introduced into the bladder; the pressure varies from 10 to 30 cm. of water. When 400 to 700 c.c. were introduced there was an extreme desire to micturate; the pressure varied from 13 to 53 cm. of water.

Centres for Urination.—Several points relative to the centre for urination are still in dispute. In general three centres are mentioned: centres in the sympathetic system, centres in the bladder, and centres in the cord.

The older experiments of Nussbaum, Nawrocky and Skabischewski and others have demonstrated the inferior mesenteric ganglion as one of the centres which lie outside of the cord. Frankl-Hochwart and Fröhlich were able to stimulate the anal sphincter reflexly from this ganglion.

Von Zeissl, from his experiments, believes that there must be an automatic nervous apparatus in the bladder itself. His experiments carried out in dogs consisted in completely isolating the bladder from the central nervous system, as well as from the sympathetic system. The animals retained urine and were able to empty the bladder.

Goltz and Ewald removed the lumbar and sacral cord of dogs; this was followed by distention of the bladder, due to retention of urine. Gradually this condition of paralysis improved and the urine began to be discharged spontaneously in increasing quantities, and the animals remained dry for increasingly long periods of time. Evidently the urine, by distention of the bladder walls, exercised a stimulation that caused a sufficient contraction of the bladder. A few months after the removal of the lumbar and sacral cords the animals urinated regularly and in sufficient quantity, so that no further care needed to be given them. They could not cause a contraction of the bladder by any stimulation at a distance from the bladder. Only stimuli in the immediate neighborhood of the bladder had any effect. For example, when a thermometer was introduced into the rectum for the purpose of taking the temperature the bladder was immediately emptied. The authors were undecided whether this was due to the stimulation of the ganglia lying outside the bladder or to the mechanical irritation of the bladder through the wall of the rectum. Even if the latter is the case, they believe that the nerve plexus in the bladder wall is responsible.

Müller, from his clinical and experimental results, is convinced that the centres for control of the bladder do not lie in the cord but in the sympathetic nervous sytem. After the removal of the lower segment of the cord in dogs, at first there is involuntary discharge of urine. After a time normal micturition is reëstablished and urine is discharged in a stream at regular intervals. There was no incontinence between urinations. The animals, however, do not seem to be conscious of the urination. It has long been known that centres for the bladder function lay in the ganglion cells of the pelvis. The only point in dispute is whether there are centres in the conus terminalis that preside over these centres. From his clinical and experimental results, Müller concludes that there are no such centres in the conus.

The generally accepted views regarding a centre in the cord have been denied by Müller and some of his followers. Roussy and Rossi

performed experiments on dogs and monkeys to determine the location for centres of micturition and defecation. They conclude from their experiments that the sympathetic centres are incapable of reëstablishing normal bladder and rectal function when they are separated from the spinal centres. They regard their work as a confirmation of the classical idea that the centres for micturition and defecation are in the lower part of the spinal cord. They do not deny the presence of vesicorectal reflex centres in the ganglia of the pelvic sympathetic system, but their experiments show conclusively that the sympathetic centres alone cannot maintain normal bladder and rectal function when isolated from the spinal centres.

It is quite possible that there are two centres, one for the sphincter and one for the detrusor.

Griffiths is disposed to regard the ganglia of the pelvic plexus as capable of acting as reflex centres, just as the inferior mesenteric ganglion is said to be by Lakowin and others. These views were corroborated by Stewart in his experimental work.

Peripheral Nerves.—Experimental work has demonstrated rather conclusively that the motor fibers for the bladder are found in the second and third sacral roots and in the nervi erigentes. According to Stewart the fibers of the sympathetic group are carried regularly in the third, fourth, and fifth lumbar roots, but the strands leading the impulses from the sympathetic chain to the inferior mesenteric ganglion vary much in position. This author was not able to demonstrate the presence in the sympathetic chain of vesicomotor fibers other than those carried in the hypogastrics. Such fibers have been described by Gaunzzi and Nussbaum.

Demonstration of the course of the sensory nerves of the bladder is attended with much difficulty, as stimulation of almost any sensory nerve of the body will cause a reflex contraction of the bladder. Mosso and Pellancani pointed out that a reflex contraction of the bladder can be obtained by stimulating the central cut end of the sciatic nerve even immediately after section of the cervicular thoracic cord.

The sacral nerves to the bladder contain sensory fibers. Stewart stated "that if the hypogastric nerves be cut to interrupt the connection with the lumbar cord and if the peripheral bladder nerves be severed close to the bladder on one side, careful stimulation of the central divided ends will produce a reflex contraction. The path of this reflex is through the sacral nerves and through the cord, for if the sacral nerves of the opposite side be then cut, or if the lower lumbar or upper sacral cord be interrupted or destroyed, the reflex fails.

Sensory fibers for the bladder are also found in the hypogastric nerves. They have their reflex centre in the inferior mesenteric ganglion.

If the terminal nerves to the bladder be cut on one side, and if the sacral supply to the hypogastric plexus be severed on both sides,

stimulation of the central divided end of the peripheral nerves gives a marked contraction of the bladder (Stewart).

Langley and Anderson describe experimental work showing that stimulation of either the lumbar or sacral nerves causes contraction of all the muscle fibers of the bladder, whether circular, oblique or longitudinal. Stimulation of the nerves on one side causes contraction of both sides, in consequence of the decussation of fibers in the inferior mesenteric ganglia.

According to von Zeissl the nervi erigentes are the motor nerves of the detrusor. Stimulation of these nerves opens the bladder, and this opening is independent of the detrusor. The effect of the erigens on the sphincter is inhibitory.

Stimulation of the hypogastric nerves closes the bladder. The hypogastrics are the motor nerves for the sphincter. The motor effect on the bladder, as a whole, is slight, and sometimes entirely absent. The law of crossed innervation holds for the bladder nerves. Thus in the erigens we have motor fibers for the detrusor and inhibitory fibers for the sphincter, and in the hypogastric motor fibers for the sphincter and inhibitory fibers for the detrusor.

The paths in the cord for the vesicomotor impulses are variously stated to be located in the anterior half of the cord (Budge) and in the lateral columns (Ott). According to the work of Stewart, which was carried out in cats, the path in the cord of all vesicomotor impulses above the centre is in the posterior part of the lateral columns only. Below the centre the impulses pass in the lateral columns.

CEREBRAL CENTRES FOR MICTURITION.

Studies relative to the cerebral centres for the bladder have been made by Bochefontaine, Franck, Bechterew and Mislawski. Bechterew and Meyer locate the centre for the sphincter vesical in the central part of the posterior part of the "sigmoidal windings abschnitt," immediately behind the outer end of the "Kreuz-furche."

Czyhlarz and Marburg believe that in man there are three cerebral centres for the bladder. A cortical centre is found in the motor area where the arm centre goes over into the leg centre, a centre in the corpus striatum and a third centre in the optic thalamus.

Frankl-Hochwart believes that both cerebral hemispheres take part in bladder innervation.

Absorptive Power of Bladder.—Whether or not the bladder has any absorptive power is still a debatable question. Guyon believes that the absorptive power of the bladder is very slight; even in pathological conditions it is very limited. Duval remarked that the normal vesical epithelium is remarkable for its impermeability, and offers an absolute obstacle to the passage of substances, and Morat and Doyon are of the opinion that the normal bladder mucosa offers almost absolute

resistance to the penetration into the blood of substances introduced into the bladder.

Nowicka, from his series of experiments, concluded that there was absorption by the bladder. He experimented with alcohol. After a long retardation the alcohol disappears from the urine in notable proportion and the quantity absorbed increases with the duration of the experiment and the degree of concentration.

Völtz, Bandrexel and Dietrich found that alcohol was absorbed from the dog's bladder and that the absorption seemed to be independent of the concentration and absolute amount of the alcohol.

Hottinger admits the absorptive power of the bladder for strychnin and cocain.

Gerota worked on dogs, cats, and rabbits, using solutions of potassium ferrocyanide, glucose, urea strychnin, and cocain. From his experiments he concludes that the bladder mucous membrane, as well as other mucous membranes, permits the diffusion of substances introduced into the bladder. This diffusion he believes takes place through the intercellular spaces of the mucous membrane.

Lewin and Goldschmidt found absorption only when the urine reached the ureters and pelvis.

Alapy did not observe intoxication in rabbits. He used strychnin, atropin sulphate, aconitin, and other highly toxic drugs.

Pousson and Segelas injected an aqueous solution of bromide of lithium. They concluded that the normal vesical epithelium is impermeable and that absorption only takes place when the epithelium is injured.

CHAPTER II.

MALFORMATIONS AND DIVERTICULUM OF THE BLADDER.

By WILLIAM E. LOWER, M.D.

MALFORMATIONS OF THE BLADDER.

Patent Urachus.—**Classification.**—The urachus, in man as in other mammals, is an impervious cord, which is embedded in the subperitoneal tissue and passes from the apex of the urinary bladder to the umbilicus. Both the bladder and the urachus persist from the allantois, which up to the middle of fetal life carries the bloodvessel from the aorta to supply the developing placenta. If for any reason this communication is not obliterated, so that after birth there remains a passage permeable from the bladder to the navel, or for any part of this distance, the condition is known variously as patent urachus, umbilicovesical fistula, urachal fistula, and vesico-umbilical fistula.

A patent urachus may occur in any one of four forms, which Vaughan[29] has designated as (*a*) complete, (*b*) blind internal, (*c*) blind external, and (*d*) blind. In the complete form the canal is open its entire length from the bladder to the umbilicus, so that the urine may escape through the navel. In the reported cases complete patency is mentioned by far the most frequently, probably because of the fact that it is impossible to overlook the condition. In the blind internal urachus the channel is patent at its lower or bladder end, and closed at the umbilicus or for some distance from that point, while in the blind external form the passage is patent at the navel end, its communication with the bladder being closed. The fourth, or blind, urachus is closed at both ends while the intermediate duct remains open, forming an elongated cyst. Vaughan, in his search through the surgical literature, found reports of 52 cases of patent urachus, to which he added one of his own. Of these 53 cases 46 were completely patent, 4 were blind internal, and 3 blind external in form. In my own series of 3 cases all were completely patent.

From the findings of a large number of autopsies, Walter and Wutz (quoted by Griffith[11]) conclude that a majority of persons have a urachus which is patent in some part of its course, but which is permanently closed at the umbilicus and has a valve (Wutz valve) at the other end, which prevents communication with the bladder. Guiteras[13] tells of investigations on 74 cadavers, made by Wutz, who found that in 69 cases out of 100 he could push a bristle along the

side of the bladder in the direction of the urachus to a depth varying from 2 to 46 mm. He also mentions the work of Luschka, who has shown that in cases in which the lumen of the urachus is apparently obliterated there may still remain some lacunæ, covered with epithelium of the same character as vesical epithelium. On the other hand, Genget, who also endeavored to establish the frequency of occurrence of this condition, in 82 autopsies on the fetus and child found the urachus permeable in only 2 cases, one a fetus of two and a half and the other a fetus of nine months. Delore and Molin report a total of 25 cases. Of the 46 cases of complete patent urachus reported by Vaughan, 26 were congenital. Castel, in 1884, reported 35 cases of congenital fistulæ, and in general the published reports of various observers would indicate that patent urachus is much more often congenital than acquired.

Various classifications of patent urachus have been suggested, the most complete perhaps being Monod's[23] modification of Bousier, as reported by Monod in his thesis published in 1899.

Congenital fistulæ	Without obstruction to course of urine	Without umbilical tumor.
		With umbilical tumor.
	With obstruction to course of urine.	Without umbilical tumor.
		With umbilical tumor.
Acquired fistulæ	Resulting from occasional cause, capable of stirring up the latent permeability of the urachus.	
	This cause is almost always an obstacle accidentally interfering with the normal course of the urine.	

Etiology.—To ascertain the etiology of congenital patent urachus requires a study of fetal life. According to Keibel and Mall,[16] "Usually the urachus degenerates at an early period to such an extent that its lumen disappears, and later the epithelial cord thus formed becomes divided into separate portions which may completely vanish before birth, but persistent remains of the urachus may for unknown reasons enlarge in a vesicular manner and give opportunities for the formation of urachal cysts. While the epithelium of the urachus completely disappears the surrounding, concentrically arranged connective tissue persists as a cord, which forms the lig. vesico-umbilicale medium."

A blind internal urachus may be converted into a complete variety by the bursting open of the closed end as the result of an abscess. The complete patency of the urachus may also be accomplished by an obstruction of the urinary tract, by urethral stricture, by cystitis (tuberculous or otherwise), by phimosis, by prostatic hypertrophy, by calculus (the cause in 2 of my own cases), or by any other condition which would cause a back pressure in the bladder sufficient to break through the lower end of the urachus and thus complete the passage between the bladder and the navel. There are cases on record in which, after prolonged retention, urine has suddenly burst forth from the umbilicus. Kirmisson[18] tells of a case reported by

Cabrol, where patency of the urachus was found in a young girl whose urethra was occluded by a membrane nearly one-fourth of an inch in thickness.

Patent urachus may be observed in all ages, the periods usually quoted being from seven to seventy-nine years. Men are more frequently affected than women, the proportion being about 3 or 4 to 1, a fact which, according to Guiges[12] and others, is due to a difference in the configuration and pathology of the urethra in the two sexes, the male urethra being longer and more bent in different places, thus presenting physiological strictures. In the series collected by Vaughan, 32 of the 50 cases, in which sex is mentioned, were males. In the 24 acquired cases of all varieties he found that the age ranged from six months to seventy-nine years, the average age being twenty-seven years. My own cases were in boys aged four, thirteen, and fifteen years.

Griffith[11] calls attention to those instances in which, although the external outlet of the urachus is concealed, there will be a constant discharge of mucopus from the navel. In such cases the careful introduction of a sterile probe through the small opening, which is more or less concealed by the folds of the umbilicus, will demonstrate the existence of a fistulous tract which extends downward in the linea alba toward the bladder. Often, if the opening in the umbilicus is plugged up with foreign matter, a small abscess forms in the navel, and when the patient applies to the surgeon for relief for this condition he is unaware that he has a congenital deformity. Griffith on two occasions found the so-called umbilical stones in this blind external urachus, the nucleus of each being some extraneous material.

Griffith adds: "In those cases in which the navel end of the urachus is closed and in those in which the bladder end of the duct is represented only by a diverticulum from half an inch to an inch in depth (as was demonstrated to be the case in the majority of cadavers examined by Binnie) there is no apparent reason why the individual in whom either of these conditions exists might not easily pass through life without a subjective symptom. But if, on the other hand, the bladder end of the urachus is patent for a distance of two inches or more, and if, at the same time, the Wutz valve maintains only partially its function, the development of any obstruction of the outlet of the bladder will be likely to cause the formation of a mural tumor representing a dilatation of the lower part of the urachus. Furthermore, the contents of this tumor, being composed, as they are, of retained urine, may undergo decomposition; in other words, an abscess may form and this abscess may either empty itself into the bladder, or may dissect a way for itself in one of two directions—outward to the surface of the body by way of the space of Retzius or downward and backward behind the bladder. . . . When both the navel and the bladder ends of this duct are closed the development of a cystic tumor may result."

Diagnosis.—The condition is very easily recognized. If the urine is discharging through the navel or through an umbilical fistula the diagnosis is evident. The urine may ooze out drop by drop, or may flow in a small stream, the latter condition being more often noted during micturition. Sometimes the region around and below the navel is painful and inflamed, and occasionally a swelling or a tumor mass may be seen in this vicinity. Cystitis is a frequent complication.

Mitchell[22] notes the following conditions which may be observed in connection with cases of this anomaly:

"(*a*) A button-like papillary projection at the umbilicus with an orifice at its summit, through which a probe may be passed.

"(*b*) The urine may escape at several points of a hernial protrusion, covered externally by mucous membrane.

"(*c*) The orifice may be a mere deficiency in the linea alba" (Treves).[27]

Treatment.—Vaughan has classified as follows the various methods of treatment used in the cases he collected:

"1. The application of caustic or of the actual cautery to the umbilical opening. Three patients were treated in this way, with 2 recoveries and 1 death.

"2. The use of the cautery and ligature or suture. Two patients were treated in this manner and both recovered.

"3. The application of ligature or suture only. Four patients were treated by this method and all recovered.

"4. Plastic operation—dissecting up the skin to cover the opening. Two patients were treated thus, with 1 recovery and 1 death.

"5. The urachus was split up, curetted or cauterized, and packed. Six patients were treated this way, with 4 recoveries, 1 death, and 1 result not given.

"6. Removal of irritation—such as removing stones from the urachus, keeping up drainage, and keeping the parts clean, sometimes using adhesive plaster to approximate the edges of the opening. Five patients were treated in this manner, with 4 cured and 1 failure.

"7. Removal of obstructions to the normal outflow of urine, as a tight prepuce, stone or tumors in the bladder, hypertrophy of the prostate gland, or stricture of the urethra. Five patients were treated in this way, and all were cured.

"8. Extirpation of the urachus and sewing or ligating the part next the bladder, as in excision of the vermiform appendix. Eleven patients were treated by this method, 10 cures, and in 1 the result was not given."

Thus of the 38 patients operated upon, 32 recovered, 3 died, and in 3 the results were not given. Of the various methods described, Vaughan feels that the fifth, that of slitting up and packing the cavity, is a rational method and ought to give good results, for there was but 1 death in the 6 cases thus treated, the cause of this death being uremia, which probably would have followed any method of

operation. The operation of choice, however, is the extirpation of the urachus with the entire diseased area, the opening into the bladder being closed by sutures. In both Vaughan's and my own series this procedure yielded splendid results, Vaughan reporting 15 cures out of 16 patients thus treated, the result in the other case not being stated. In my own series of 3 patients, where I used this operative procedure, 2 made good recoveries and 1 was a failure. The 1 in which the method failed was tuberculous, the bladder and patent urachus both being involved. In addition the boy had Pott's disease.

W. J. Mayo (quoted by Griffith) uses a slightly different procedure for the radical relief of this condition. He dissects out the tube thoroughly, excepting half an inch at the bladder end. Here he divides the duct and attached tissues, turns in the remaining stump toward the bladder, and applies a purse-string suture, leaving a small drain *in situ*. He admits, however, that in spite of all these precautions there is considerable likelihood of a persistent discharging sinus for some time.

Watson and Cunningham[30] suggest "removing the obstacle to the free escape of urine from the bladder, which is usually congenital stricture; or if this does not result in cure, in excision of the sac and closure of the communicating opening in the bladder. This step is carried out through an abdominal incision."

It is well to remember that all operative procedures on this vestige of an embryonic condition are attended with danger to life. Early operation is always advisable because of the danger that the bladder and kidneys may become infected. Delangenière (quoted by André and Boeckel[1]), in cases of congenital fistula, suggests waiting until the child is a year old. After that age there should be no delay, unless there are complications which contra-indicate operation. Of course, in the old or in patients suffering with prostatic hypertrophy the condition of the patient must decide whether operation is advisable. The first step is to search for and remove anything that may interfere with the free normal egress of urine from the bladder. In male children one should look especially for phimosis, for in the great majority of cases the cause is some obstruction to the lower urinary passage, and if this is removed the fistula will often heal spontaneously.

Absence of the Bladder.—Absence of the bladder is an abnormal condition, usually accompanied by other deformities, particularly by the termination of the ureters in some unusual position. Gould and Pyle[10] tell of cases reported by Blanchard, Blasius, Heller, Nebel, Rhodius and Leiutant. Winter[31] has also published a case in which the meatus urinarius, vestibule and labia majora were imperfectly formed, consisting merely of little folds of skin about an inch long, one and a half inches apart posteriorly and two inches apart anteriorly. The ureters discharged externally, their terminations being nearly two inches apart and situated just inside the anterior edge of these little folds of skin. The patient, a child of eight years, had suf-

fered with a constant dribbling, which had caused almost constant inflammation of the part.

As a rule nothing can or need be done for a case of absence of the bladder unless the ureters open into the vagina externally when they may be transplanted into the rectum.

Double Bladder.—Double bladder apparently occurs more frequently than absence of the bladder, although many cases of so-called double bladder are doubtless in reality cases of diverticulum of the bladder. The occurrence of triple and even of quintuple bladder has also been noted. The indication for treatment depends upon the inconvenience caused by the deformity, and the technic is governed by the individual case.

Exstrophy of the Bladder.—Exstrophy or ectopia of the bladder is probably the most intolerable of all human malformations, as the constant expulsion of urine from the exposed ureteral orifices causes constant annoyance to both the patient and those near him. Moreover, unlike many other deformities, this is a condition to which time brings neither amelioration nor adaptation. Fortunately, the condition is not of frequent occurrence. Statistics show that it probably does not occur more than 1 in 30,000 or 40,000 births, and that 50 per cent. of the individuals born with this anomaly die before the age of ten; that it occurs more frequently in the male than in the female, the proportion being about 5 to 1; and that it is often combined with other malformations, such as imperforate anus, spina bifida, prolapsed rectum, etc.

Etiology.—Many theories as to the cause of this malformation have been proposed, but as yet its exact etiology is not definitely known. Brandl,[4] of Germany, has made such an extensive study of this condition that I shall quote quite extensively his statements regarding its etiology. He has found that the various theories fall naturally into two groups, the main contentions of the adherents of the first group being that bladder exstrophy results from the intra-uterine rupture of a completely formed bladder, while the general principle advanced by adherents of the second group is that ectopia is a pure anamorphosis.

Some of the supporters of the first principle are Duncan, Müeller, Rokitanski, Schutze and Winkel, their belief being that in the course of fetal development the urethra becomes closed and causes retention of urine. "The pubic bones which at this time are scarcely cartilaginous and still ununited are kept apart until they become hardened. At the same time the recti muscles are kept apart, so that little by little, by the intravesical pressure of urine, the bladder presses against the abdominal wall and finally ruptures and forms adhesions to the borders of the split."

The stand-point of those who accept the second principle is thus explained by Ahlfeld: The vitelline sac for some unknown reason is misplaced and forced to the tail of the embryo, and "if, for example, in consequence of sudden filling of the amniotic cavity by fluid, a

violent traction, the proctodeum, is forced toward the symphysis, it will push the allantois before it and thus prevent fusion with parts arising on both sides. Thus the abdominal wall and symphysis remain split, and in consequence of this, organs lying on either side, which after their fusion should form the genitalia, cannot meet.

"The allantois forms a large bladder, and as the excretory duct cannot develop downward the sac fills and finally ruptures, by which the anterior wall is lost, the posterior alone remaining. So long as the fetus is contained in the membranes and the abdominal contents and amnion are subjected to an almost equal pressure the ectopic bladder is concave, but as soon as birth takes place the bladder walls become projecting on account of back pressure from the intestines."

Brandl thinks that this theory is not generally applicable, at least when the splitting is not complete. He also disagrees in part with Ahlfeld's assumption that in almost all cases of fissura vesicæ the terminal gut is involved in the malformation, and that in the more marked types of ectopia a preternatural anus exists.

Another theory discussed at length by Brandl is that of Thiersch, who "assumes that at the time when division of the sinus urogenitalis and rectum takes place the symphysis is already united, as a small projection of skin, the so-called genital protuberance, is seen. This originates when the two corpora cavernosa, which develop at the same time as cartilaginous pelvic bones unite, become united, and the glans then develops on them. While this goes on the perineum becomes lengthened and pushes the orifice of the sinus urogenitalis before it toward the lower border of the symphysis, and by union with the genital protuberances forms the urethra. If, however, the division of the cloaca and the upward progress of the sinus urogenitalis occurs before union of the symphysis takes place, that of the corpora cavernosa does not unite at all, or only imperfectly, since the place they were to occupy has been taken by the sinus urogenitalis. Consequently, no urethra can be formed, so having no outlet the bladder fills and finally ruptures."

As Brandl suggests "the fault of this theory is that it assumes a non-union of the symphysis, and for this reason Thiersch himself has adopted Duncan's ideas."

Still another theory is that of Rose (also quoted by Brandl), who attributes the defect to a failure of union between the pubic bones resulting from some injury to the mother during gestation. This theory also is not applicable to all cases. Rose thought also that every case of fissura vesicæ was due to a patent urachus; but Brandl takes exception to this belief, since it does not explain those instances in which there is a normal umbilical cord and no fistula of the urachus.

Brandl himself seems to support Duncan's theory that it has been proved, experimentally and otherwise, that the bladder functionates actively during fetal life. This theory explains also malformations of the urethra and penis.

Among those who believe that exstrophy is due to an arrest of development may be mentioned Watson and Cunningham[30] and Chetwood.[7] According to Kelly and Burnam[17] "exstrophy arises from failure of the tissues of the embryo, which go to form the abdominal walls, to meet in a median line, a defect in the prevertebral laminæ analogous to hare-lip, cleft-palate, congenital omphalocele, and spina bifida."

C. Arthur Ball[2] in an article on extroversion quotes several other hypotheses, namely, that exstrophy is "due to defective development; not solely of the urogenital apparatus, but to a failure of junction between the lateral segments of that portion of the somatopleure, whose duty it is to furnish the anterior surface of the body, which extends from the umbilicus to the floor of the urethra, together with a cleft condition, anteriorly, of the allantoic vesicle.

"1. Keith's view that 'Certain chambers in the embryo, such as the neural canal and pericardium, are liable to a dropsy and rupture. Were the cloaca of the embryo to be ruptured along its ventral wall the condition of ectopia would be produced.'

"2. That the vesical cleft is caused by bursting of the overfull bladder. This theory rests upon the dilatation of the ureters and renal pelvis, so often found associated with vesical cleft. But Kauffman found that the secretion of urine does not begin until the end of the second month, long before which time the symphysis is formed. He therefore supposes that the symphysis becomes separated again in those cases of vesical cleft in which it is found open."

Signs and Symptoms.—Brandl,[4] following Winkel, classifies the various forms of this congenital defect, whatever the grade of the malformation, as follows:

1. Defects of the bladder at its lower portion, the pubis being united.
2. Defects of the bladder at its upper part, the pubis being united (fissura vesicæ superior), and this is the rarest type.
3. Typical ectopiæ of the entire bladder.

The condition is very easily recognized as the characteristic signs of the condition are obvious (Fig. 8) and the region so sensitive that the clothing must be kept away from the exposed surfaces.

The anterior abdominal wall is split, the bladder wall exposed, and the bladder extends into the lower hypogastric region. Protruding into the region of the pubis is a reddened, inflamed tumor-like mass which is very tender to the touch. "Upon closer examination no actual defect of the abdominal wall is found, there being only a separation of the recti muscles. The extent of the gap varies; it is almost always confined to the mons veneris, but some instances are recorded in which it has reached as far up as the xiphoid process. In complete cases there is always a separation of the symphysis pubis varying in width from 2 to 8 cm, the gap being filled by connective tissue" (Brandl).[4]

The urine may be seen constantly trickling from the ureters and when the patient sneezes or coughs or makes contraction of the abdominal muscles, the urine is forced out in jets. The symphysis is usually separated, the prepuce split, and the urethra is exposed, malformed, or may be entirely lacking.

The following conditions may be noted in the male: the penis is short, rudimentary, and often epispadic; the prostate may be lacking and the testicles too are frequently epispadic. The prepuce is occasionally noted as a lifeless appendage.

Fig. 8.—Usual appearance of ectopic bladder.

In the female the clitoris is apt to be split, the labia rudimentary, and the urethra, as in the male, may be absent. Other conditions often associated with exstrophy are prolapse of the rectum, inguinal hernia, spina bifida, uterus bicornis, and simple or double vagina. Cases have been recorded in which neither the uterus nor the uterine appendages were present.

Treatment.—Although surgeons have devoted much time and thought to attempts to relieve patients afflicted by bladder exstrophy, no method as yet devised affords more than temporary relief.

Some surgeons, among them Roux, Nélaton, Pancoast, Thiersch, Ayres, Billroth and Wood, have attempted to make a substitute bladder wall by applying to the freshened edges of the anterior defect flaps turned down from adjacent parts. One serious objection to this method is the fact that the hairs soon become covered with urinary salts, a circumstance which not only causes much annoyance and pain, but may also provoke calculus formation.

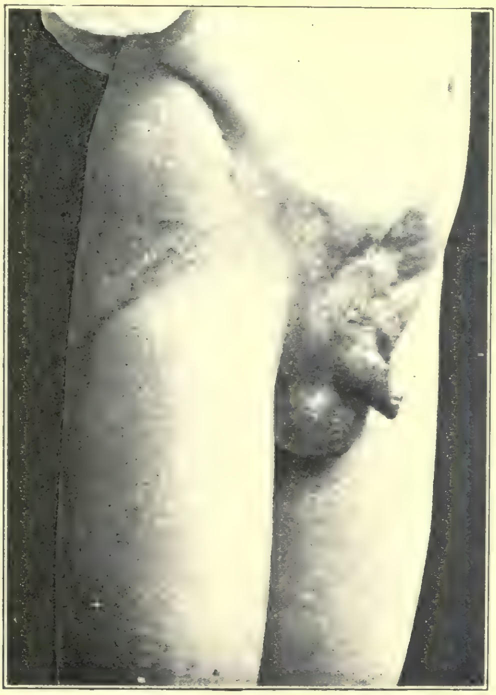

Fig. 9.—Result of operation for ectopia vesicæ after the method of Trendelenburg. (Trendelenburg.)

Some surgeons have endeavored to form a small cavity which would serve as a urinary reservoir, the most successful operation of this character being that devised by Trendelenburg. His method consisted in uniting the separated bones at the symphysis and then closing the vesical cleft by a plastic operation. In this way he succeeded in covering over the exposed bladder, thus rendering it capable of some urine retention and producing some sphincteric action as well, as is shown in Fig. 9. Trendelenburg suggests that the operation be done before the child is seven or eight years old, as in adults the operation is more difficult and dangerous. In most cases, however, this operation, if satisfactory at all, succeeded only in covering the exposed organ, but not in any restoration of bladder function, the urine continuing to

trickle down over the pubis, so that the wearing of a urinal was necessary.

FIG. 10.—Transplantation of the ureters onto the skin. (Author's case.)

Another method—and one to be recommended—is the transplantation of the ureters either onto the skin at a more convenient place for wearing a urinary receptacle or to some structure where the urine

can be retained for some time, as, for instance, the rectum. The first method, the transplantation of the ureters onto the skin of the back, usually has given satisfactory results. This operation as originated by Ballance and Edwards in 1886, and modified by Watson, consists in bringing the ureters to the skin on the back. This may be done by making transverse incisions through the skin and muscles; exposing each ureter, dividing each at a sufficient distance from the kidney and bringing it out to the skin surface at the inner angle of the wound,

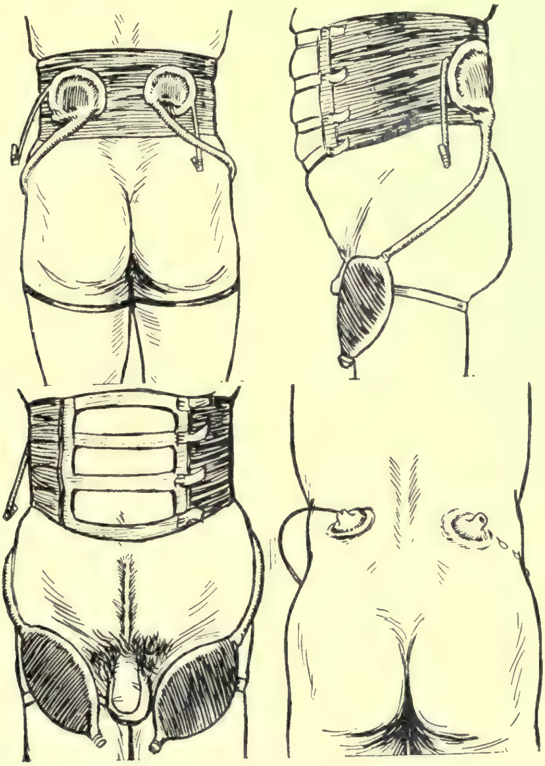

Fig. 11.—Apparatus applied. Four and one-half inches from centre, two inches from crest. (Peterkin.)

where it is either stitched, as shown in Fig. 10, or, as is perhaps better, allowed to protrude far enough to avoid its recession by contraction. Some prefer to expose the kidney by the usual vertical oblique incision, and then with a blunt instrument to force a way obliquely through to the skin in the back, where an incision is made through which the ureter is drawn. The ureters must not be drawn too tightly, and allowance must be made for contraction. It is also necessary to make sure that there is no angulation or other obstruction to the flow of urine. This location of the ureters makes possible the firm attach-

ment of a urinary receptacle. Among the reported cases are some of patients who have thus been able to get about very comfortably. In a very interesting case reported by Peterkin a device was used which could be brought around in front of the patient and easily emptied (Fig. 11).

One objection to the transplantation of the ureters to the back is that as the opening is out of the patient's sight the visual adjustment of the urinary receptacle is difficult. To obviate this difficulty, Harrison (1896) removed one kidney and transplanted the ureter from the other to the skin of the loin. Bottomley (1907) slightly varied this procedure by "removing neither kidney, but transferring both ureters to the skin of the loin." Bottomley suggests two objections to this operation: the possibility that the ureter and kidney may become infected as a result either of contraction of the orifice or of excoriation of the skin in its immediate vicinity, and the fact that no sphincter is provided. As to the danger of infection, he believes that if the kidneys are in a healthy condition before operation and the patient will use intelligent care and cleanliness afterward, infection from skin implantation will rarely if ever result. As to the absence of the sphincter, Bottomley thinks this disadvantage is more than counterbalanced by the greater safety afforded the patient.

Although skin implantation has been satisfactory in certain cases, it seems to the author that the method of choice is the transplantation of the ureters to the sigmoid, as it has been found that the sigmoid will retain the urine for from one to three hours, or even longer, and without any notable local irritation.

The various operative methods which have been devised to this end comprise either (1) the division of the ureters and their transplantation directly into the sigmoid, or (2) the transplantation to the sigmoid of that part of the bladder which contains the ureteral orifices in order that the ureteral valves may protect the ureters against infection.

Mayo is of the opinion that "the best theoretical and practical operations, when they can be employed, are those which permit the ureters to traverse some distance between the mucosa and the outer wall of the bowel before penetrating its lumen, or are infolded by the wall of the bowel for a space, and next those methods in which the base of the bladder is transposed and made a part of the rectal wall."

He states also that in the Mayo Clinic "the Stiles plan of doing the operation in two stages, with an interval of from one to three weeks between, was followed." Judging from their (Mayo's) experience, he thinks these operations are not successful in children, who are too young to attend to their own bowel movements.

According to Stiles[26] "the permanent fixation suture is applied on the Witzel gastrostomy principle. Two parallel folds of intestinal wall are united over the implanted ureter by means of fine linen thread" (See Fig. 12).

Martin's operation, those of Maydl and Makkas, and the Peters-Bergenhem operation each possess so many points of merit that it seems well to quote at length the description of each.

Martin Operation.[21]—"The principles of my operation are as follows:

"1. The ureters empty into the bowel in the direction of its long diameter, and from above downward, so that the urine is discharged in the direction taken by the fecal current.

"2. The ureters are buried in the walls of the rectum for a distance of an inch or more longitudinally, so that in the act of defecation the fecal mass will squeeze the caliber of the ureters closed by its pressure

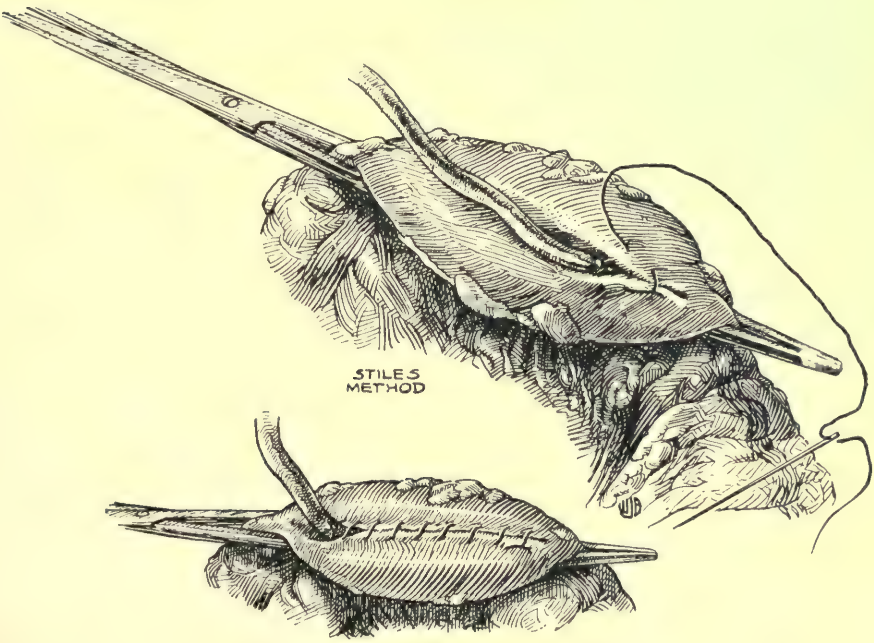

FIG. 12.—Infolded ureter in large bowel similar to Witzel's gastrostomy. (Mayo.)

on the mucous membrane, and that pressure is exerted from above downward in the direction of the onward flow of the urine, thereby emptying the ureter by a milking process.

"3. The ureters are further protected by the muscular coat of the intestine. This is accomplished by surrounding them in their longitudinal course through the intestine to the extent of 2 cm. by the circular coat of the bowel. This muscular coat of the bowel, in acting from above downward, milks the urine downward and holds the ureters closed when the rectum is aiding in defecation. When the contraction and closure due to defecation is over the urine will spurt with considerable force, acting as its own cleanser.

"4. The ureters are implanted in the lower bowel, which is normally empty except at defecation."

Coffey,[8] in 1911, devised a modification of the Martin method, which he describes as follows:

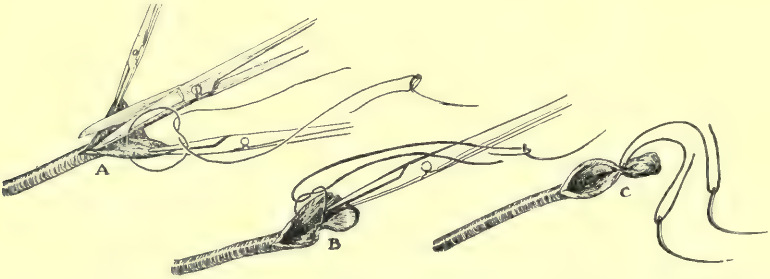

FIG. 13.—Preparing the duct for implantation into the intestine: *A*, splitting the duct to provide for drainage and tying the suture around half of the duct; *B*, tying suture around split duct; *C*, split duct ready for insertion. (Coffey.)

"First, the duct is located and ligated with linen or silk. It is then cut in two above the ligature and the edges caught and held with mosquito forceps while one wall of the duct is split down with a pair of scissors, as shown in Fig. 13, *A*. A linen suture is now passed through the split end of the duct so as to include about one-half of it, and tied (Fig. 13, *A*). The linen thread is then thrown around the other half and tied (Fig. 13, *B*). The loose ends are then threaded into two

FIG. 14.—Incising peritoneal and muscular coats of intestines and freeing the mucous membrane from the muscular coat. (Coffey.)

needles. By this method the full strength of the duct is retained for traction, while the opening is maintained by the split (Fig. 13, *C*). The end of the duct is now wrapped with gauze while the intestine is prepared for its reception, which is done as follows:

"The part of the intestine desired is picked up and an incision made down through the peritoneal and muscular coats, including submucous tissue, until the mucous membrane pouts out through the incision (Fig. 14). This incision should be about one inch long or more. Second, five or six sutures are passed which pick up the peritoneal and muscular coats on each side of the incision. The suture at the upper end of the incision is tied as a control suture. The intermediate intestinal sutures are lifted up on the flat handle of an instrument as they cross the incision. Now the intestine is brought down close to the end of the split duct and the two needles carrying the threads (traction sutures) on the end of the duct are passed beneath the four or five intestinal sutures and through the stab wound in the mucous membrane into the intestinal lumen and out through the

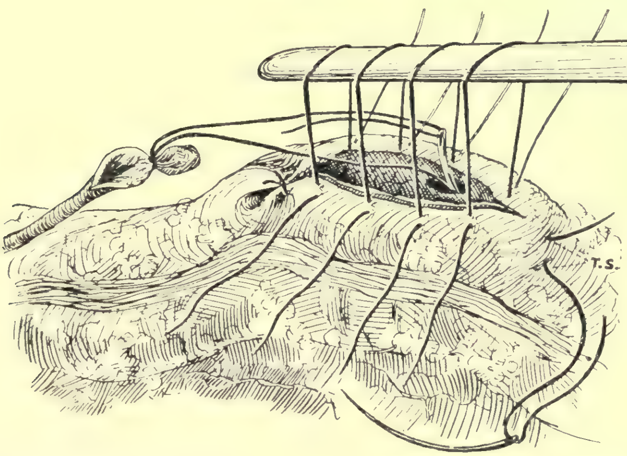

FIG. 15.—Sutures have been passed and duct is being drawn under the intestinal sutures through the stab wound in the mucous membrane. (Coffey.)

intestinal wall three-quarters of an inch farther along the intestine, and one-eighth to one-quarter inch apart. By making tension on these threads, and at the same time pushing the intestine toward the duct, the duct is drawn beneath the intestinal sutures through the stab wound into the intestinal lumen, when the two ends of the threads on the duct are tied on the outside, thus anchoring the end of the duct on the inside of the intestine at this point (Fig. 15). The intestinal sutures are then tied, producing the result shown in (Fig. 16.) After this operation the duct lies just beneath the mucous membrane, which has been loosened for approximately three-quarters of an inch of its course, so that it slides easily in its new channel. It is therefore necessary to tack the ureter to the peritoneum of the intestine near its point of entrance by two or three fine linen or silk sutures. Care should be used to take only the outer coat of the ureter in the bite of

these sutures. Thus practically all the steps of the operation are completed before the intestinal mucosa is penetrated and no sutures penetrate the lumen of ureter. The traction suture at the end of the ureter within the intestine and the two or three anchor sutures fastening the duct to the intestinal peritoneum are the only means of retaining the duct in place. The same intra-intestinal force which later prevents regurgitation into the ureter now prevents the intestinal contents from leaking back by the loosely implanted ureter.

"To prove the mechanical correctness of the theory of this operation, make a hole in the side of a rubber bag; insert a rubber tube and cement it; cement a flap of thin rubber over the end of the tube; connect a fountain syringe filled with fluid with the tube and fill the bag. If the syringe is now disconnected it will be found that no leakage from the tube takes place."

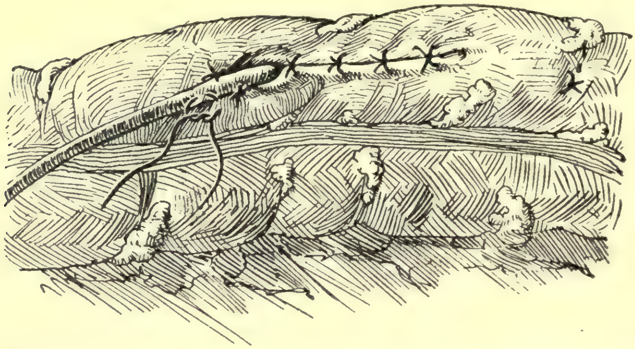

Fig. 16.—Duct has been implanted and anchored at its end inside intestine by tying tract on suture. Peritoneal sutures have been tied. Anchor suture being placed to fasten duct to peritoneum. (Coffey.)

Maydl's Operation.[3]—"Excise all the exposed vesical mucosa except that portion immediately around the orifices of the ureters. Carefully cleanse the wound and field of operation after the excision of the filthy mucous membrane. Open the abdomen. Find the sigmoid and bring a loop of it out of the wound. By stripping, empty the gut of its contents. Apply an intestinal clamp or tape above and below the part selected for anastomosis. Incise the gut longitudinally. With through-and-through sutures unite the edges of the portion of bladder wall attached to the ureters to the edges of the wound in the sigmoid. Cover this line of suture by a line of continuous Lembert sutures. The result is that the remnant or ellipse of bladder wall is inserted like a patch into the incision in the sigmoid. Note that no great separation of the lower ends of the ureters from their surroundings is required; the loop of sigmoid is brought down to the ureteral portion of bladder, which is, of course, mobilized. The implantation of the segment of bladder wall containing the ureters, instead of the

implantation of the ureters themselves, is the important principle in the operation; by it the normal ureteral valves or sphincters are retained and infection is prevented from ascending the ureters. Several modifications of Maydl's operation have been suggested, but most of them merely complicate the technic."

The Peters-Bergenhem Operation.—A method very similar to that of Maydl is the Peters-Bergenhem operation—an extraperitoneal implantation of the intact ureteral orifices into the rectum. According to Buchanan,[5] although this is called the "Peters operation" in America and Great Britain, Bergenhem, "was the first to devise it, the first to practise it, and the first to publish it."

Peters[24] describes his operation as follows:

"Both ureters having been isolated, the whole of the bladder tissue was remorselessly ablated from the perimeter, where it merged into the skin, to the prostate, where the vesiculæ seminales debouched. (During this dissection great care must be taken not to expose or injure the peritoneum; and if its hazardous proximity be suspected, a portion of the bladder muscle may be left, though every vestige of its mucous membrane must be removed.)

"The next step was to expose the lateral aspects of the rectum at a point below the reflection of the peritoneum. The deep dissection was found to be surprisingly easy, and by pressing back the retrovesical cellular tissue I was able to expose the anterior and lateral walls of the rectum with readiness. This part of the operation was greatly facilitated by an assistant, who inserted his finger into the rectum and lifted it into the wound.

"The final step of the operation was the implantation of the ureters into the lateral walls of the rectum, and this was accomplished in the following manner:

"With his finger in the rectum the operator carefully determines the exact point at which the implantation is to be made. The requisite qualifications are: (1) It must be above the internal sphincter; (2) It must be in the lateral and not in the anterior wall, so as to avoid kinking; (3) It must be high enough up to permit the ureter to project slightly (say one-quarter to one-half inch) into the lumen of the bowel without stretching. If the ureter thus projects it forms a papilla, which when pressed upon from within the bowel becomes converted into a valve, similar to that at the entrance of the bile duct and the salivary ducts. This point having been decided upon, the operator or his assistant passes a slender forceps through the anus, presses it against the ureter from the rectal aspect, and lifts it carefully into the anterior wound. The wall of the bowel is now incised upon the projecting forceps, which is then forced gently through. By stretching and cutting the wound is enlarged with great exactness, so that the ureter with its contained catheter will accurately fill it and yet not be injuriously pressed upon. The forceps is now opened, made to grasp the distal end of the catheter, and withdrawn into the bowel and out of

the anus, the operator at the same time carefully directing the ureter through the slit, and satisfying himself that its termination forms a papilla at least one-quarter of an inch long upon the rectal mucous surface. In guiding the mouth of the ureter through the slit in the rectal wall forceps may be passed back again beside the catheter, and made to grasp the edge of the rosette of bladder tissue around the ureteral papilla. This process is repeated upon the other side. The sponge plug is now withdrawn, care being taken not to disturb the catheters while doing so.

"There seems to be no necessity whatever for stitching the ureters in position, and in my case the attempt was not made. The catheters are left in position at least two or three days, or until they come away of themselves, which occurred in my case in about sixty hours.

"*The Dressing.*—I do not think it judicious to attempt any plastic operation for immediate closure of the abdominal wound. The whole area to be healed will be found surprisingly small, and a moderately firm packing with iodoform gauze will afford efficient drainage, and at the same time furnish a support and splint to the delicate ureters in their new position. When the implantation has healed securely, and granulation has been established, a plastic closure may be done if it be deemed advisable. I allowed my case to heal entirely by granulation, and the scar is quite small and firm."

Makkas' Operation:

"Stage I. Step 1. Open the abdomen by an incision through the right rectus muscle.

"Step 2. Examine the cecum. If the cecum cannot be pulled to the middle line, mobilize it by incising the parietal peritoneum parallel and close to its outer side.

"Separate the cecum by blunt dissection from its posterior connections exactly as in cecectomy but carefully preserve intact its blood supply.

"Step 3. Divide the ileum close to the cecum and close both the distal and proximal segments of the gut.

"Step 4. Divide the ascending colon above the cecum and close both the proximal and distal segments of the colon.

"Step 5. Make a lateral anastomosis between the proximal segment of ileum and the distal segment of the colon (or the sigmoid).

"Step 6. Perform appendicostomy, bringing the appendix out through a special opening. (Bringing the appendix out through an opening made by splitting the muscles of the abdominal wall as in the McArthur-McBurney operation would, it appears to the author, provide an excellent sphincter to the appendix.)

"If appendicostomy seems inadvisable or impossible because of adhesions, small size of the appendix, etc., perform cecostomy.

"Step 7. Close the abdomen.

"*After Treatment.*—After the lapse of ten days pass a Nélaton catheter through the appendix daily and irrigate the cecum.

"Stage II. This stage is practically identical with the Maydl operation except that the mobilized portion of bladder wall attached to the ureters is implanted into the lower part of the segregated cecum instead of into the sigmoid. When the operation is completed the new bladder must be kept empty by a catheter introduced through the appendix.

"In Makkas's case the catheter was clamped after eight days and the new bladder emptied every two or three hours. At first the capacity of the bladder was only 100 c.c. After four weeks the capacity increased to 300 to 325 c.c., and the bladder required to be evacuated every three or four hours through the day, but not at all during the night.

"If the catheter was removed while the bladder was full there was no escape of urine, but this continence was not absolute, as drops of urine escaped when the patient moved about. The urine was not albuminous but contained mucus. The necessity of leaving the catheter *in situ* permanently is a disadvantage, the lessening of the dangers of ascending infection is a great advantage over the Maydl method."

Which of the various methods of transplanting the ureters into some portion of the intestine should be the operation of choice is difficult to determine. No large enough series by any method has been presented to establish its merits to the exclusion of all others. On theoretical grounds one should employ either some method like Maydl's, in which the normal ureteral openings are retained, or else the method practised by Martin, Coffey and others, in which the ureters are transplanted into the gut in such a way as to simulate as nearly as possible the normal anatomical condition.

Whether the infection of the kidney, which in the majority of cases follows operation always proceeds from the gut up the ureters, or whether it is extended through the lymphatics, is not definitely known. In this connection Le Conte,[19] discussing Mayo's paper on "Exclusion of the Bladder," says: "Recent animal experimentation at the University of Pennsylvania, with transplantation of the ureter into the bowel, would seem to show that ascending infection of the kidney does not take place through the lumen of the ureter, but through the lymphatics accompanying the ureter. When the ureter was anastomosed to a rubber tube, and the rubber tube anastomosed with the bowel, infection of the kidney did not take place. Secondly, with the direct anastomosis of the ureter and bowel a low-grade inflammation was always found in the coats of the bowel at the site of the anastomosis. It would therefore seem that the more oblique the passage of the ureter through the bowel the larger will be the zone of bowel inflammation, and the greater the number of ureteral lymphatics that will come in contact with this low-grade inflammation. As obliquity of the ureteral passage through the bowel is necessary for a tight joint, some method of blocking the ureteral lymphatics in this region should be devised, in order to safeguard our patient from ascending infection of the kidney."

Buchanan, discussing the same paper (Mayo's), said he thought that "the reason we have ascending infection in these cases in which the ureter is severed in its continuity is because we have the cut end of a mucous canal, and if we notice the tendency to contraction that occurs in the end of the urethra in amputation of the penis, then we can easily understand how this cut end of the ureter will contract, and that contraction means dilatation of the ureter and pelvis of the kidney, predisposing to infection."

One fact is self-evident, if the patient survives any operation by which the ureters are transplanted into the gut his life is made tolerable. In these cases the risk should be taken even if the risk to life be rather great.

DIVERTICULUM OF THE BLADDER.

Diverticulum or *sacculation* of the bladder, these names sometimes being used interchangeably to define the same condition, is more prevalent than was formerly supposed, the present more frequent discovery of the condition being due to the fact that an absolute diagnosis is impossible without the aid of the cystoscope or the x-rays, although occasionally a fairly accurate diagnosis may be made by exclusion.

The etiology of bladder diverticulum is still *sub judice*. Some contend that this condition is always congenital, while others maintain that it is always acquired, basing the contention principally on the presence or absence of muscular fibers in the sac.

Englisch (quoted by Fischer)[9] believes that "These obstacles may be produced by inflammatory conditions of the bladder or urethra, during intra-uterine life, but which have healed out, leaving no vestiges after birth. . . . the opposing epithelial layers become agglutinated during embryonal life, occluding the urethra. This occlusion is relieved at a later date by the back pressure of the secreted urine."

Lerche,[20] on the other hand, does not consider that the congenital origin of diverticula can be based on either the presence of muscle fibers in large diverticula, or the termination of one of the ureters in the sac. Muscle tissue has been found in a large acquired diverticulum; while in one case at least, shown by Targett, an obstruction to micturition caused by an enlarged prostate resulted in the termination of one of the ureters in the sac. He discusses a case of his own in which "the fibrous changes in the neck of the bladder have been the slow cause of the trabeculation of the viscus and of the formation of the diverticulum. The trabeculation of the bladder proper, the absence of trabecula in the diverticulum, and the shape of the orifice of communication, would rather be in favor of the view that the diverticulum has originated late in life. The almost straight lower margin of the diverticular orifice suggests that that shape has been determined by an hypertrophied bundle of muscle, and that the formation of the diver-

ticulum therefore has taken place secondarily to the trabeculation caused by the obstacle to urination. If that is the case the vesical end of the ureter has simply become gradually shifted into the diverticulum in the course of its development by pressure. The anlage, however, may have been congenital in the sense regarded by Englisch."

In discussing the origin of diverticula arising at or near the ureteral opening, Joly[15] says that it occurred to him "that these diverticula might be due to the persistence and enlargement of supernumerary 'ureteric buds'." He endeavored to collect evidence in support of this hypothesis and came to the belief "that supernumerary ureteric buds not infrequently fail to reach the developing kidney; that these may remain as tiny congenital diverticula throughout life, or, from some reason at present unknown, perhaps from the inherent power of the embryonic cells to multiply, they may increase in size. Once this happens, a certain amount of urine is suddenly forced into them every time the bladder contracts. Before these repeated shocks they dilate still more, and sooner or later lose the power of emptying themselves. Still every contraction of the bladder transmits a wave of increased pressure through the vesical opening; this acts as an expansile force within the diverticulum and tends to increase its size. They resemble aneurysms in this respect, that the larger they are the greater is the pressure, which tends to increase still more their size."

Speaking of the case of a child, two and a quarter years, operated by Stiles, he (Joly) says: "This is a connecting link between the blind ureteric buds and the true congenital diverticula and shows how the one may develop into the other. What happened here to an apparently normally growing ureter that failed to meet the rudiments of the true kidney may also be conceived to occur in cases of supernumerary ureters even though a normal ureter may also be present."

Cabot[6] is of the opinion that "the word 'diverticulum' should be confined to those cases of pouches, always of congenital origin, occurring most frequently in certain positions but occasionally seen in almost any portion of the bladder and not due to defective development or lack or closure of any recognized structure." Cabot does not agree with Chute, who believes "that they originate in the little pouches normally seen just above the ureteric orifice, and that they become important only when this pouch is exaggerated as the result of obstructive pressure," because of "the fact that they are so frequently found in individuals in whom obstruction is totally absent, in whom in fact the symptoms of obstruction are due, not to any obstruction, but to the diverticulum. I incline to the view that when found in individuals with urinary obstruction, they are an accidental finding and of no etiological significance. That they are due to some embryonic defect is clear, but I have as yet seen no adequate explanation of their formation beyond the fact that they are associated with peculiarities of the closure of the cloaca, perhaps with a tendency to budding from this structure."

In a paper published shortly after this one, he (Cabot) states that "the acquired type must obviously be due to obstruction in the urinary tract at some point below the bladder, and it behooves the advocates of the theory that they are acquired to produce evidence of obstruction as it also behooves those who hold the view that they are congenital to show that these patients are not guilty of obstruction." After citing 10 cases, only 2 of which showed clinical evidence of obstruction, he says: "Upon the evidence submitted, and which I have been able to collect from other sources, it seems to me far more probable that these sacculations are of congenital origin, that they may, and do, exist for years without causing symptoms which, when they appear, depend upon the advent of infection."

The fact that some sacs contain muscular fibers and others only mucous membrane, is not sufficient ground upon which to base a differentiation between congenital and acquired diverticula. The probability is that a certain per cent. of the cases are congenital or rather there is probably a congenital defect in the bladder wall, which under given conditions acts as a predisposing cause to the development of a diverticulum. From my own personal experience, however, in observations upon 24 cases of diverticula, I believe that in practically all cases this condition is acquired, this opinion being based principally upon the following points: (1) Diverticula are scarcely ever found in the very young, but for the most part occur in persons past middle life, an age at which obstructions to the urinary outlet most frequently occur. Necropsies on children rarely show this condition, or at least its presence is not mentioned in most postmortem records. Such anomalies as hour-glass or double bladder, which are occasionally reported at postmortem findings in children, are generally associated with double urethras or multiple ureters and other abnormalities and should not be considered identical with true diverticula. (2) Only about 10 per cent. of the reported cases of diverticula occur in women. (3) In most cases the bladder wall is much thickened, a condition generally present when obstruction to the urinary outlet is indicated. This indicates that the same condition that produced trabeculation, which is generally caused by obstruction, may cause diverticula. Kelly and Burnam[17] refer to a series of 17 cases of diverticula collected by von Dam,[28] in only 1 of which—and this a doubtful case—was a diverticulum found in a woman. In addition, they (Kelly and Burnam) report 3 other cases of diverticula in women found in the literature and 1 case of their own. In the 1 case of a woman in my own series, a urethral caruncle was present which caused her so much pain that she refrained from voiding except at long intervals, and never completely emptied her bladder.

As yet no experimental data have been offered to prove any theory thus far advanced, and until some unassailable proof can be furnished the exact etiology of diverticula will remain unsolved.

Symptoms.—Frequent urination with inability to completely empty the bladder is one of the most common signs of the presence of a diverticulum. In most cases these symptoms do not cause any special annoyance until infection and cystitis develop, when the patient seeks advice because of the pain accompanying these conditions. Occasionally a burning or stinging sensation is felt during and after micturition. If the diverticulum has existed for some time, the kidneys may become infected, and pyelitis, pyonephrosis or hydronephrosis may develop. Catheterization may not result in the withdrawal of much urine after the patient has voided, for the catheter may not enter the orifice of the sac. If the diverticulum be infected, the urine, even after repeated irrigations, is cloudy and in a great many cases is very fetid. If the diverticulum be very large, a definite tumor may be detected by rectal or vaginal examination, or even by abdominal palpation. Hematuria frequently occurs also. In many cases, and especially in elderly men with prostatic obstruction, the symptoms of diverticula may be entirely overshadowed by the prostatic condition.

FIG. 17.—Diverticula of the bladder. X-ray photographs before and after removal of the diverticulum, and also specimen after removal.

Diagnosis.—The presence of diverticula can nearly always be determined by the cystoscope in the hands of a person experienced in its use, but may be easily overlooked by the inexperienced. The diverticulum opening is sometimes so very small that it looks like a mere dark speck in the field. This apparently insignificant speck, however, may be the opening into a very large sac. If the presence of a diverticulum is evident or is suspected, the diagnosis may be made certain and the size and exact location of the sac determined by the aid of collargol and the x-rays, as shown in Figs. 17, 18 and 19. A posterior sac may be overlooked by an anteroposterior picture, but it can generally be detected by taking a picture at an angle. This seems to be a more exact method than to measure the size of the sac with a ureteral catheter.

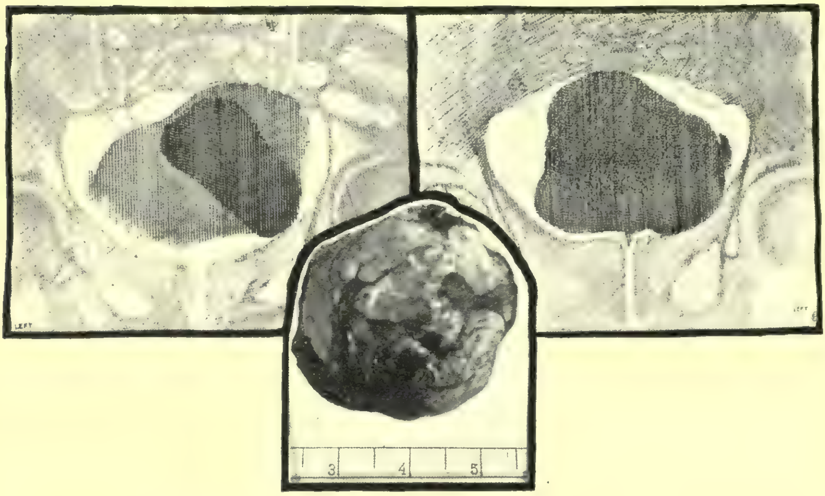

FIG. 18.—Diverticula of the bladder. X-ray photographs before and after removal of diverticulum and also specimen after removal. They also show a small, shallow diverticulum which was not removed.

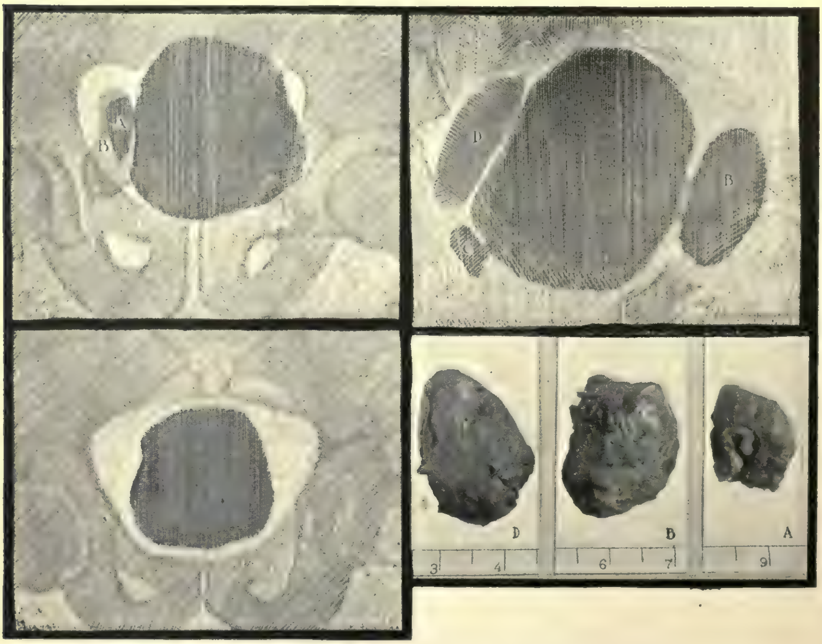

FIG. 19.—Diverticula of the bladder. X-ray photographs of multiple diverticula: *1*, anteroposterior views, showing diverticula *A* and *B; 2*, view taken at an angle, showing diverticula *B*, *C* and *D*; *3*, bladder after removal of diverticula; *4*, *A*, *B*, *D*, specimens after removal.

Kelly and Burnam[17] think that a very good method to take the *x*-ray picture is "to inject a heavy bismuth emulsion into the diverticulum and then introduce a solution of less specific gravity into the bladder, say the iodide of silver emulsion 2 to 3 per cent." Another method which has been quite successful is the Brown-Osgood, which consists of introducing a shadow or stilletted catheter, pushing it up until it coils into the cavity, and then taking a radiograph. In many cases the diverticula contain calculi, a complication which may be advantageous in the treatment as is described later.

Treatment.—If the opening of the diverticulum be small and the sac large, as is frequently the case, and if infection be present, palliative treatment will be of no avail, for, as it is impossible to cleanse the diverticulum thoroughly, the infection cannot be checked. Unless radical measures be taken, infection, in all probability, will ascend and will produce secondary and often fatal renal involvements.

Many operative measures have been advised, but the most efficient is the radical removal of the sac. This procedure is often extremely difficult and until within the last few years has not been generally practised. In his report in 1912 Lerche collected 14 cases in which diverticula had been excised, and to this list appended 1 of his own. Since then additional cases have been reported by Cabot, Chute, Bergener, Bryan, Marion, Beer, the author, and others. In most cases excision has been followed by permanent good results. To a large extent, however, the success of excision depends upon the technic. To completely excise a collapsed mucous sac is extremely difficult, but unless all of the mucous membrane is removed, the condition is almost certain to recur. Occasionally it is possible to dissect down to the diverticulum and to completely close the opening into the bladder, after which the mucous pouch may be removed.

The technic of excision is influenced considerably, however, by the location of the diverticulum. Cabot describes as follows his technic for the removal of diverticula on the posterior or lateral wall, not in proximity to either of the ureteral orifices: "The bladder having been opened and the finger introduced into the pouch, the bladder wall is incised freely down to the neck of the pouch, which is then circumscribed, a clamp applied to the pouch and the rest of the dissection rapidly finished. The incision in the bladder wall, though long, has not seemed to me objectionable, and it greatly facilitates speed and avoids unnecessary trauma to the surrounding tissues."

It often happens that a diverticulum is situated near one of the ureteral orifices so that the ureter empties into it; in such a case the ureter must be resected and transplanted, or both the ureter and the diverticulum must be dissected out by the ingenious flap method described by Young.

Cabot's method in such a case is "to isolate the ureter on one or both sides, according as the pouch was unilateral or bilateral in the neighborhood of the iliac vessels. The ureter is then clamped lightly

with a Crile clamp to prevent wound contamination by the urine, opened and a good sized gum-elastic bougie passed to the bladder and left in place. This maneuver renders the identification of the ureter easy at all times and removes the danger of its accidental incision or division. The difficulty next met with is the separation of the pouch from the surrounding tissues, to which it is generally firmly welded. It has generally seemed unwise to split the bladder wall down to the orifice, as is done in the posterior or high lateral wall cases, and particularly is this undesirable in bilateral diverticula. The separation of the sac is in some cases much facilitated by packing it with gauze, thus giving a firm mass on which to dissect and rendering the identification of the tissue easy. Our greatest difficulty has lain in the fact that these pouches are so surrounded by scar tissue and glued to everything in the neighborhood that it is by no means easy to distinguish them from other important structures, as, for instance, the rectum. After the pouch has been thoroughly freed (it generally must be done with the scissors and cannot be freed by blunt dissection) it may be drawn upward by means of a clamp and the neck of the sac freely divided. The wound thus left can generally be closed without difficulty, though in the cases situated below the ureteral orifice the adherence of the bladder wall to the surrounding structures sometimes makes closure without tension difficult."

Cabot emphasizes the following points: "Free bladder incisions carried down to the orifice of the sac in the more accessible cases. The opening of the ureter and the placing of a guide bougie in all cases where the diverticulum is in the neighborhood of a ureteral orifice, and finally, the constant drainage of the ureter for some days in those cases in which resection has been necessary or the flap operation of Young has been possible."

Kelly and Burnam suggest the following technic: "In making the abdominal incision to reach and effect a radical removal of the diverticulum, one may make one of four openings: (*a*) vertically in the median line, or (*b*) and (*c*) laterally through one of the recti muscles, or (*d*) horizontally through the fascia parallel to the pubic rami; the recti muscles are then pulled apart until the bladder is well exposed and can be handled in the attack upon the diverticulum" (Figs. 20 to 24).

The method which I have found most satisfactory and which is applicable in practically all cases, is to convert the sac into a solid or semisolid tumor by the method incidentally described in a case reported by Cabot in 1912. The bladder is opened so as to expose the orifice of the diverticulum, which is then packed tightly with narrow strips of gauze, as shown in Fig. 24. By this means a tumor is produced which can be easily palpated and manipulated. The bladder is next freed down to the attachment of the diverticulum, which is then cut away from the bladder, when in most cases it can be removed easily with forceps, as shown in Figs. 25 and 26. In those

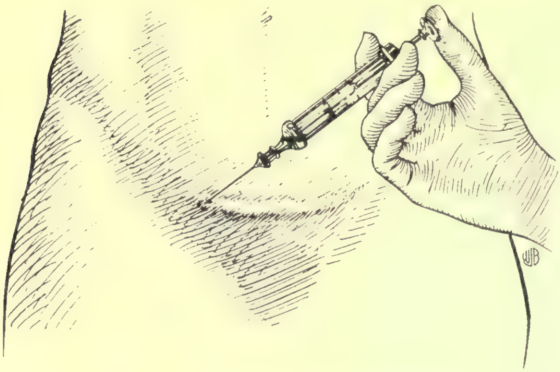

FIG. 20.—Local infiltration of novocain.

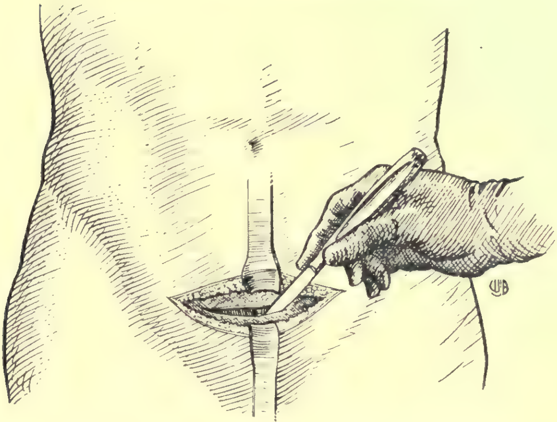

FIG. 21.—Transverse incision through skin and fascia.

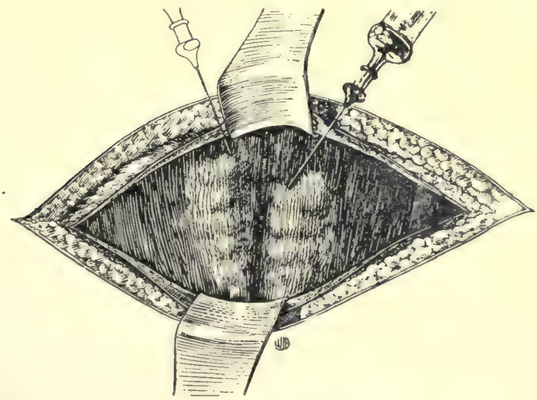

FIG. 22.—Infiltration of recti muscles with novocain.

cases in which the sac contains a large calculus or is packed with small calculi, the diverticulum may be resected with the calculi intact, as they furnish the same condition by gauze packing. In some cases, however, the sac adheres closely to the surrounding parts and must

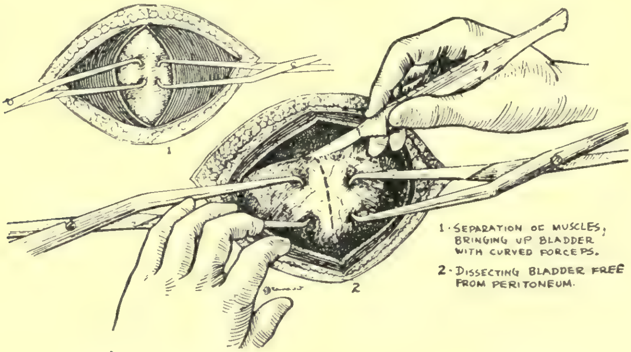

Fig. 23.—Elevation of bladder with curved forceps.

be separated carefully by a sharp dissection. The opening into the bladder is either closed and drainage instituted by means of a catheter in the urethra, or a drainage tube is inserted into the bladder from above and the bladder closed around it. Immediate closure of the

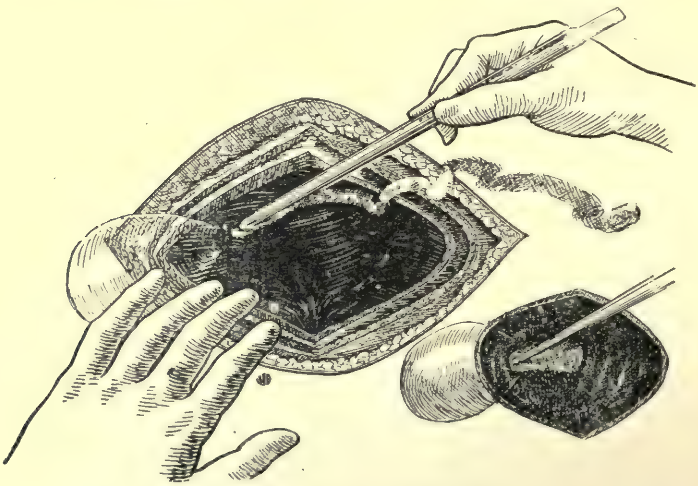

Fig. 24.—Packing of diverticulum.

bladder is preferred whenever possible. I have found few cases in which closure at the primary resection is impossible. A piece of gauze or of collapsible drain should be placed outside the bladder in the prevesical space from which the diverticulum has been removed. If

there be much oozing, it may be advisable, instead of packing, to drain this space through an incision into the perineum. Lerche described a method of using a small rubber bulb which is inserted into

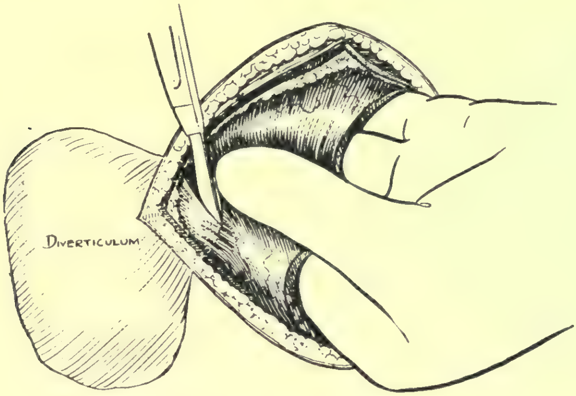

Fig. 25.—Division of sac at attachment.

the diverticulum and then inflated. This answers the same purpose as the packing, but is not as easily accomplished. In most cases I think it is preferable to do the operation extraperitoneally, but when

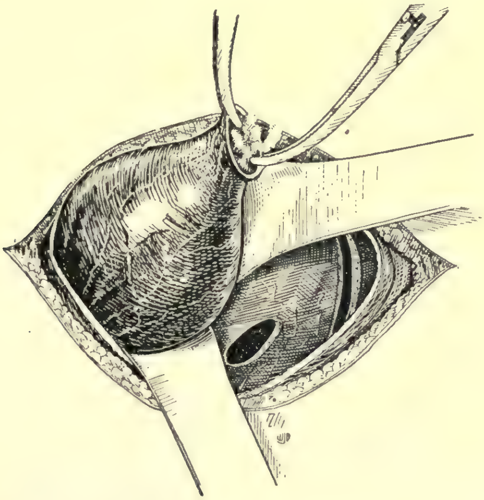

Fig. 26.—Delivery of diverticulum.

this does not seem feasible, a transperitoneal operation may be performed. When it is not possible to make a complete resection, the necessary resort is to palliative measures, which consist in so enlarg-

ing the opening into the diverticulum as to obviate so far as possible the danger of urine retention.

In all cases an obstruction to the bladder outlet should be sought, and if found, remedied; an enlarged prostate should be removed; a stricture of the urethra should be dilated; a caruncle should be excised. I am quite confident that in certain cases where the diverticula are multiple, as in Fig. 27, and it is impossible to remove them all, a simple removal of the obstruction will do much toward alleviating the condi-

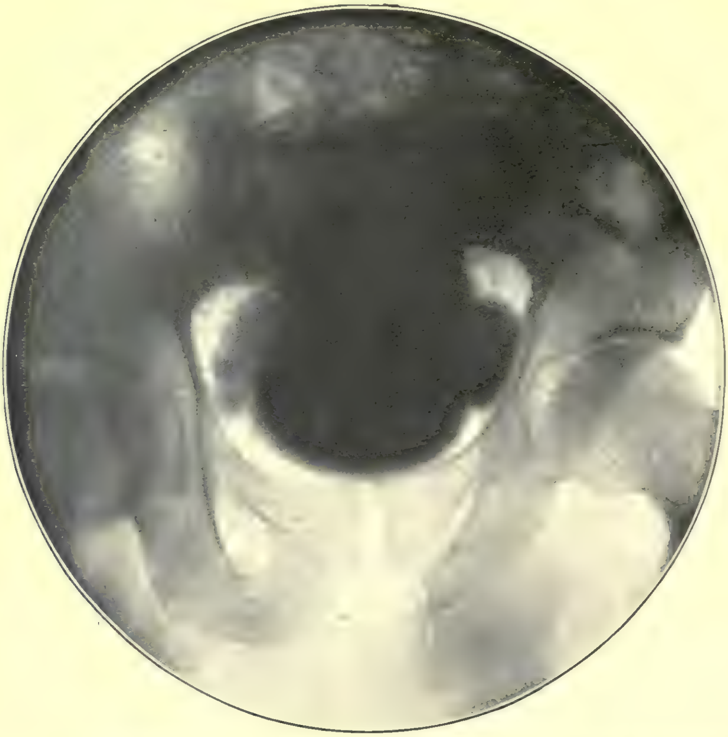

Fig. 27.—Diverticula of the bladder. X-ray photograph of multiple diverticula, which were too shallow for operative treatment.

tion. In two such cases of my own, much improvement followed the removal of the obstructions, as this released the back pressure and prevented a further distention of the diverticulum. In one case in which the prostate was removed and nothing else done except to keep the bladder clean, the diverticulum was distinctly smaller at the end of two months. Similar cases have been described by Young.

In speaking of operations to remove urethral obstruction without attempting to attack the diverticula, Young[32] says that while no definite cases of this kind have been reported in the literature, "many

have undoubtedly occurred in conjunction with enlarged prostate in which prostatectomy, or the Bottini operation, has been performed." To further quote him: "I have had a great many cases in which diverticula were present, but in which they caused no symptoms and were not of threatening character, where I was content to remove the prostatic obstruction, and have been gratified to find that the diverticula have given no trouble and have apparently gradually diminished in size. Where definite obstruction is present and the diverticulum not threatening, one should always try at first the operation for removal of that obstruction (urethrotomy or prostatectomy), but that cases will be found in which this will not suffice is shown by the cases which I have recorded."

An interesting case, reported by Hagner,[11] was that of a man, aged seventy-four years, who had complained of prostatic obstruction with complete retention. "Rectal examination showed a fairly large prostate—abdominal palpation revealed a large bladder with a sausage-shaped tumor extending upward toward the right lumbar region. On catheterization 65 ounces of urine was obtained—cystoscopic examination showed an irregular intravesical prostate with lateral and median enlargement and a definite postprostatic pouch. A small diverticulum was seen on the left side of the bladder with the opening just to the outer side of the ureteral opening; on the right side of the bladder a large diverticulum was observed with the opening at a point where the posterior and lateral wall of the bladder meet.

"Prostatectomy was advised and performed (suprapubically), patient making a good recovery. I had advised removal of the large diverticulum as I felt otherwise he would still have a residual urine. As an experiment just before the suprapubic wound healed I filled his bladder with fluid through the urethra, closing the suprapubic wound with my finger; he was then able to pass with force a considerable amount of the injected fluid. He was then catheterized and showed 16 ounces residual.

"Realizing the diverticula were responsible for this residual, I again filled his bladder and had him stand up and pass out all fluid possible (the finger keeping suprapublic wound closed), then he was cystoscoped through the suprapubic wound. This was easily done, as there were 16 ounces in his bladder. The patient was then directed to make an effort to urinate; immediately the light was obscured by the meeting of the bladder wall, no fluid escaping from the urethra or the suprapubic wound. He was told to continue his effort to urinate, and the cystoscope was directed into the large diverticulum which could be easily cystoscoped while he strained. As soon as he discontinued the effort to urinate the fluid would run out of the diverticulum into the bladder when the diverticulum could no longer be cystoscoped on account of its collapsing. The smaller diverticulum holds very little, the larger one holds approximately 16 ounces.

"This patient is apparently in excellent condition; can hold his

urine during sleeping hours, has no frequency during the day and passes a good forceful stream.

"He always has 15 or 16 ounces of residual urine and refuses any further operative intervention at this time, as he is perfectly satisfied to be able to urinate naturally.

"I made an effort at the time of prostatectomy to evert the large diverticulum just as you would turn a glove inside out, but adhesions prevented.

"I was able to do this in one case, removing the diverticulum by excising it from within the bladder."

The method described by Squier[25] in the case that he reports is especially applicable to those diverticula in which the ureter opens directly into the sac, as the danger to the kidneys which is incident to ureteral transplantation, will thus be avoided. "First, two slender intestinal anastomosis clamps were introduced, one blade of each into the diverticulum, the other into the bladder, clamping the posterior wall of bladder to the anterior wall of the diverticulum, the direction of the clamps being downward and inward from diverticular opening to internal vesical meatus.

"The walls of the bladder and diverticulum were divided between these clamps. The cut edges were then carefully approximated with a running catgut stitch, thus converting into one the cavities of bladder and diverticulum. The upper portion of the diverticulum was then excised and the bladder wound closed, greatly reducing the size of the newly formed bladder. The bladder was drained by a suprapubic tube. Closure of peritoneum and abdominal wound followed, and cigarette drainage of the prevesical space completed the operation."

Summary of Technic of Operation.—In every case in which I have removed a diverticulum by first converting it into a solid tumor the following method was used:

1. Nitrous oxide-oxygen anesthesia with local infiltration of novocain (Fig. 20).
2. Transverse incision through skin and fascia (Fig. 21).
3. Infiltration of muscles with novocain (Fig. 22).
4. Separation of muscles, elevation of bladder with curved forceps, and dissection of bladder free from the peritoneum (Fig. 23).
5. Packing of diverticulum tightly with gauze (Fig. 24).
6. Exposure and division of the attachment of the sac and the bladder wall, the fingers being placed inside the bladder, the index finger in the opening of the diverticulum, and the thumb on the outside (Fig. 25).
7. Dissection of diverticulum free from surrounding tissue. In some cases this last step is not necessary, as the diverticulum was not attached to the surrounding tissue and could therefore be drawn out without difficulty. In these cases by means of traction on the sac the division of the attachment to the bladder was accomplished more readily than by the method described in Step 6.

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CHAPTER III.

INJURIES OF THE BLADDER.

BY FRANCIS R. HAGNER, M.D.

Introduction.—Although taken collectively traumatic affections of the urinary bladder are met with very rarely in surgical practice, one finds that considerable space has been devoted to the subject in medical literature. This extensive interest in the subject is probably due to the seriousness with which the older surgeons regarded this subject at a time when at least the intraperitoneal varieties of bladder injuries were believed to terminate almost always fatally.

Indeed, the history of the surgical treatment of bladder injuries reflects in a very convincing manner the highly progressive stage which modern surgery has attained.

Historically, it is of interest that wounds of the bladder were described in the earliest times. In an historical sketch by Evans and Fowler[4] we are told that Homer, in the Iliad, refers twice to this accident as rapidly fatal. Hippocrates, Aristotle and Galen have likewise written on the subject. Coming down to more modern times we find that the first laparotomy for the relief of rupture of the bladder with recovery reported in the literature was performed by an American surgeon, Walther, of Pittsburgh. It is extremely interesting to note that of the 131 cases of intraperitoneal injury to the bladder reported in Bartels's[1] statistical study all terminated fatally except Walther's case. The case of Walther, although in his surgical interference he did not suture the peritoneal wound, forms an important event in the history of this subject, as it marked the turning-point to the rational treatment of these affections.

In 1817 D. J. Larrey,[6] a French army surgeon, published the first comprehensive contribution to the subject, based on material gathered from his extensive experience in the Napoleonic wars. It is generally conceded that this was the first attempt at a complete and systematic study of bladder injuries. The studies of Stephen Smith (1851), Demarquay (1851), Houel (1857), and George A. Otis (1876) form the next noteworthy contributions to the subject. The work of Otis[8] is particularly noteworthy.

Max Bartels's[1] paper, "Die Traumen der Harnblase," which appeared in 1878, forms the next landmark in the history of this subject. This paper was extensively reviewed by Evans and Fowler[4] in their very excellent and lucid contribution which appeared in the *Annals of Surgery*, 1905. The exhaustive study of these authors

summarizes the cases reported in the literature between the years 1878 and 1905, and may be looked upon as the standard statistical study up to that date.

Since then some noteworthy studies on rupture of the bladder have appeared in medical literature, especially by the Russian observers Galaktionow,[5] Dobrowolskaja and Wiedemann.[3]

Definition.—While ordinarily in discussing traumatic affections of the urinary bladder only wounds of this viscus are taken into account, it is deemed advisable to include also in this contribution such traumatic insults as contusions and ruptures. This distinction has practical significance, especially when one keeps in mind the question of the relative incidence of these various affections. According to Bransford Lewis[7] the term "wound of the bladder" indicates not only a break in the continuity of the bladder itself but also of the skin and the soft parts surrounding it. By rupture is understood a solution of the continuity of the bladder, without wound communication with the external surface.

Classification.—The following seems to be the most convenient classification of traumatic affections of the bladder.

(*A*) Contusions of the bladder.

(*B*) Wounds of the bladder.

(1) Punctured wounds produced either by sharp or blunt instruments.

(2) Bullet wounds.

(*C*) Rupture of the bladder.

Depending upon the location of the wound, and whether or not it involves the peritoneal covering of the bladder, the various injuries may be classified as:

(1) Extraperitoneal.

(2) Intraperitoneal.

(3) Subperitoneal.

Surgical Anatomy.—Owing to the rather marked variations in the shape, size, and location to which the urinary bladder may be subject, both in health and disease, variations which play an important role in the proper diagnosis and treatment of injuries to this viscus, it is deemed advisable to give here a brief summary of its topographical anatomy. Hugo Wichmann,[10] in his thesis on punctures of this organ, gives a very practical anatomical description of the same.

The bladder is located immediately behind the symphysis pubis, to which it is connected by rather loose connective tissue, and above which it extends in the adult only when in a distended state. In the fetus and child, on the other hand, the bladder is always held above the symphysis pubis by the very short vesical ligament. As a result of this the bladder here appears to be more of a spindle shape and more flattened from before backward. Posteriorly, the bladder is in relation in the male with the seminal vesicles and with the rectum, while in the female the vagina and cervix uteri lie behind the bladder,

with which organs it is connected by means of a rather loose connective tissue. From the body of the uterus it is separated by the anterior pouch of Douglas. Of the greatest importance in connection with traumatic affections of the bladder is its relation to the peritoneum. The peritoneum runs from the anterior abdominal wall over the summit of the bladder and covers its posterior surface down to the base of the trigone in the male, while in the female it only runs to the point of junction between the middle and lower thirds of the organ. The sides of the bladder are likewise free of peritoneum except behind and above. Inasmuch as the summit of the distended bladder extends beyond the point of attachment of the urachus, there forms between it and the abdominal wall a peritoneal pouch. The anterior wall of the bladder is entirely free from peritoneum. In the distended bladder the peritoneal covering is stretched out smoothly over the underlying organ, while in the empty bladder it falls into a series of folds which lie close to the bladder wall, the lowest of which embraces the rectum, and is the broadest one, corresponding to that portion of the peritoneum which pulls upon the most markedly arched part of the bladder during its contraction.

Close to the pouch of Douglas there are at least four more folds, one pair of which originates from the body of the bladder and ascends obliquely upward and outward toward the sides of the pelvis, while the other pair lies deeply and contains the urethra.

Even in the anterior abdominal wall the topography of the peritoneum varies with the degree of bladder distention. In the contracted state of the bladder the peritoneum covers the entire anterior abdominal wall and even part of the anterior boundary of the pelvis, while a much-distended bladder so elevates the anterior peritoneal lining that the entire anterior surface of the distended bladder comes to the fore and may be punctured at any point in its elevated position in the abdominal cavity without injury to the peritoneum. The above relationships are, of course, subject to variations in accordance with the physiological functions of this organ. The bladder is an elastic pouch which changes its shape as well as its position in accordance with the degree of its distention.

The influence of neighboring organs upon the bladder must likewise be kept in mind. It is well known that the uterus when it enlarges pushes the bladder forward. The seminal vesicles and small intestines do not affect this organ; on the contrary, they are affected by it. Progressive distention of the rectum is accompanied by a corresponding elevation of the bladder along with which the prostatic and membranous portions of the urethra experience a stretching and lengthening. As has already been alluded to, the distance between the symphysis pubis and the lower limits of the peritoneal lining of the anterior abdominal wall varies with the position of the bladder. When the bladder and rectum are empty this distance is only a few millimeters. In its empty state the summit of the bladder does not

quite reach the rim of the pelvis; when medium full it extends 1 or 2 mm. above the symphysis, and when markedly distended it fills the entire pelvic cavity, forms quite a tumor in the hypogastrium, and extends 3 to 5 mm. above the symphysis pubis.

It might be well to mention here that, according to the experiments of Rauber, the capacity of the male bladder is 735 c.c., while that of the female is 680 c.c.

The bladder may be injured both in its distended as well as in its empty state, though it is very well protected in the latter state by the pelvic walls.

The points which we wish to emphasize particularly from the above anatomical considerations are the following: (1) The bladder may have an extremely varying shape and position in the abdominal cavity. (2) In its empty and contracted state it forms a triangular pouch flattened from before backward, and is situated deeply in the pelvic cavity, its summit not quite reaching the pelvic brim. (3) When medium full it assumes a more globular shape, fills more completely the pelvic cavity, and its summit reaches somewhat above the anterior part of the brim of the pelvis. (4) When markedly distended it assumes a more oval shape, with the long diameter running longitudinally, its summit reaching at times as high as the umbilicus.

Keeping the above points in mind, one readily realizes what a wide range of exposure to injury the bladder may have, a fact of considrable differential diagnostic importance.

With these general considerations we may proceed to the detailed discussion of the various traumatic affections of the bladder.

CONTUSIONS OF THE BLADDER.

We know of no available statistics concerning the frequency of this affection. According to Bransford Lewis[7] the condition is rarely met with in practice, and the chief point of importance connected with this injury is its differential diagnosis from rupture of the bladder, an error which may have serious consequences. The injury is usually sustained from a kick or fall, and may be of varying degrees of severity. Pain and some degree of temporary shock is usually observed. If the bruise to the bladder is severe enough it may cause extensive disarrangement of the vascular system of the organ, with vesical hematuria, impediment to the flow of urine due to clot formation, tenesmus, and at times a severe cystitis. Depending upon the degree of injury to the bloodvessels of the organ, the hemorrhage may be severe enough to cause death. The issue of a given case depends, of course, as in all bladder injuries, to a large extent upon the condition of the bladder and urine at the time of injury. If the urine is not sterile, severe sepsis may set in, which may terminate fatally.

If clot formation is extensive enough to interfere very seriously with urination, catheterization may have to be resorted to, a procedure

which deserves unusual care, owing to the disposition to infection present in a contused bladder. The same precaution is to be carried out in the use of other instrumentation. We have particularly in mind the use of the cystoscope for diagnostic purposes and of Bigelow's evacuator for the purpose of clearing the bladder of clots, a therapeutic measure which may have to be resorted to. The patient should be treated in bed. Application of hot-water bags and morphin internally may have to be resorted to for the relief of pain and tenesmus. The bladder should be washed out several times a day with boric acid solution to disintegrate and remove blood clots, and the urine should be kept or rendered aseptic by the stomach administration of salol and boric acid, and should be kept diluted by the free use of bland fluids. Hemorrhage usually ceases on relieving distention; if it does not, more radical measures must be resorted to (Da Costa[2]). A point which may well be emphasized here is that in alcoholics and in those having a distended bladder from any cause a very slight injury which ordinarily would cause only a mild contusion may cause rupture of the bladder.

WOUNDS OF THE BLADDER.

Under this heading will be considered punctures and bullet wounds of this organ.

Frequency.—Owing to the anatomical location of this viscus and the protection afforded to it by the surrounding bony pelvis it is peculiarly immune from injuries due either to direct or indirect violence, and it is generally agreed that wounds of the bladder are very uncommon in surgical practice; especially is this true of civil practice. Thus Evans and Fowler[4] state that among 10,867 surgical cases treated at the Bethany Hospital in eight years there were only 3 cases of bladder injury, while only 2 such cases occurred among the 16,711 surgical patients admitted to St. Bartholomew's Hospital between 1869 and 1895. In the 408,072 cases reported in the War of the Rebellion not a single case of punctured, incised, or lacerated wound of the bladder was reported, and there were only 183 cases of bullet wounds. Considerable speculation has been resorted to to explain this infrequency of bladder injury, and it has been suggested by some that it may be only relative, and that a great many of these patients, especially on the battlefield, succumb to the injury in a few hours without ever reaching the hospital. This, according to Wichmann,[10] is untenable, inasmuch as patients with severe bullet wounds of the bladder have not only lived long enough to reach the hospital, but even several days later. In this connection, however, one must keep in mind the point raised by Larrey,[6] namely, that while all accidental injuries of the bladder are very serious, those produced by shot are less dangerous than the others. However, there can be no doubt of the absolute rarity of these injuries. In connection with the point of entrance, it is very interesting to note that, contrary to what one

would expect, the hypogastric region is not the most common one. Even in the fierce hand-to-hand fighting on the battlefield, when bayonet charges are resorted to, the bladder escapes injury. Up to 1905, according to Evans and Fowler,[4] not a single case of bayonet wound of the bladder has been recorded.

Etiology.—As is the case in all forms of bladder injury, here too the *full bladder* is the vulnerable bladder and more subject to direct and indirect assaults, although as has already been pointed out, the empty bladder is not immune from injuries. In contradistinction to rupture of the bladder, puncture wounds and bullet wounds usually involve a normal bladder, the contents of which are sterile.

The bladder may be pierced by stab and bullet wounds, by falling on a picket or stake, by an attack from a horned animal, by penetration by a fragment of a fractured pelvic bone, and, finally, accidentally by various surgical instruments. It may be reached by penetrating instruments in three principal ways: (1) through the suprapubic region, (2) the obturator foramen, and (3) the perineum. At these three points the bladder is directly exposed to injury, being unprotected by the bony pelvis. In Bartels's 50 cases of punctured wounds of the bladder 22 occurred in the perineo-anal region, 20 in the region of the abdomen, 1 through the obturator foramen, and in 7 the point of entrance was not given. In the 25 cases collected from the literature by Evans and Fowler,[4] one of which was their own case, the location of the entrance wound was as follows: 12 perineal, 5 gluteal, 3 abdominal, 1 sacral, 3 groin, and 1 thigh. Thus in point of frequency we find (1) perineum, (2) hypogastrium, and (3) obturator. The point of entrance varies somewhat with the nature of the instrument producing the wound. In Bartels's[1] 50 cases the wound was produced by a sharp instrument in 26 instances, by a blunt instrument in 20 instances, while 4 were gored by a horned animal. In Evans and Fowler's[4] 25 cases 10 were produced by sharp instruments and 15 by blunt instruments.

Symptoms and Diagnosis.—While the symptoms and diagnostic features of wounds of the bladder are in many respects the same as those of rupture of the bladder, still there are certain features associated with wounds of this organ which make it advisable to consider the symptomatology of the two conditions separately. In all cases of injury in the vicinity of the bladder the most important points to be settled as soon as it is possible are the following two: (1) Is the bladder itself involved by the injury, and (2) is the injury intraperitoneal or extraperitoneal? (In the total of 504 cases of injury to the bladder reported by Bartels's 131 were intraperitoneal and 373 extraperitoneal in nature.)

After the receipt of an injury which causes a wound in the bladder, the patient usually experiences a more or less pronounced degree of shock. Pain in the lower abdominal region may be very severe. Excessive desire to void urine, but inability to do so, and a symptom espe-

cially emphasized by Wichmann,[10] namely, the absolute helplessness of the patient, with inability to walk. This helplessness may reach a stage of complete collapse. The further subjective symptoms will vary with the type of injury, whether intraperitoneal or extraperitoneal.

Objectively blood *mixed* with urine is seen to escape from the external wound in varying quantities, the escaping urine becoming clear only after a day or two. Usually the wound channel can be readily followed by a probe for varying degrees of depth even into the bladder, which clearly establishes the diagnosis. This, however, is not always the case. If the injury was received in a full and distended bladder, which collapses following the escape of the urine either through the natural or unnatural channel, the bladder wound will no longer be in alignment with the skin wound and thus render the diagnosis from objective signs more difficult. The escape of urine through the outside wound may for the same reason be interfered with considerably, and before a positive diagnosis can be made catheterization will have to be resorted to. We have already pointed out the danger of catheterization in these cases, and one may state without reservation that this procedure should always be avoided in cases of injury to the bladder whenever it is possible to get along without resort to it. Not a few cases of intraperitoneal ruptures have been reported in which peritonitis has developed only following catheterization. The escape of blood mixed with urine is present in most cases of penetration of the bladder, and when present is absolutely diagnostic. This sign may be absent, however, especially when the wound was made by a small, sharp instrument, and may become effectually closed for the time being by a clot. In these cases if the patient is unable to void urine catheterization must be resorted to, in order to make an early diagnosis, as well as cystoscopy and fluid injection. The withdrawal of bloody urine by means of the catheter is likewise diagnostic of bladder involvement, though one must not forget that bloody urine is likewise present in contusions of this viscus and injuries of the kidneys. The hemorrhage may be very severe if the inferior epigastric artery is injured.

Once we have established the fact that the bladder has been injured there still remains the more important question of the nature of the injury, whether intraperitoneal or extraperitoneal. This phase of the subject will be discussed in connection with ruptures of the bladder.

The point at which the wound may take place in the bladder varies considerably, but it seems that in injuries from without inward, the upper part of the viscus is more readily injured. In wounds from within outward, such as are produced by instruments through the vagina or uterus, or by penetration by a spicule of bone in fractures of the pelvis, a skin wound is wanting and additional signs are those of extravasation of urine into the surrounding tissues. This complicates the picture considerably, especially in the extraperitoneal variety where extensive infiltration of urine may take place. The patient

begins to experience severe burning sensations, a diffuse swelling takes place, of the scrotum, penis, the inner side of the thighs, and the inguinal and lower abdominal regions. If the patient has been free from fever thus far there soon develops a high septic temperature, often initiated by chills and collapse. Difficulty in passing urine increases, and the patient experiences severe pain in endeavoring to micturate. Peritonitis may likewise develop along with this. In a certain number of cases the course may be a much more acute one. The swelling from the infiltration assumes enormous dimensions in a very short time, gangrene and sloughing set in very rapidly, and perforation follows with the discharge of urine mixed with foul-smelling pus and slough detritus. In fortunate cases the infiltration does not proceed any further. The patient becomes very much better soon after free discharge has been established, repair gradually sets in, and at most there may remain a urinary fistula. Other less resistant cases succumb to the severe toxemia.

Another complication may be the retention in the bladder of a part of the penetrating instrument or of pieces of clothing carried into the organ at the time of the injury. The resultant symptoms are those of a foreign body in the bladder. In most instances these symptoms set in acutely, after the foreign body has been in the bladder for a considerable length of time. Bloody urine, insistent desire to urinate, with difficulty in voiding urine, and symptoms of cystitis supervene.

Treatment.—Of the utmost importance in the treatment of wounds of the bladder is early diagnosis, a point which will be discussed more fully in connection with ruptures of this organ. Once a diagnosis of bladder injury is established, surgical interference must be resorted to. The treatment of the intraperitoneal variety will be discussed in connection with ruptures. In extraperitoneal wounds the chief danger to be avoided is extravasation, and the surest way of preventing this is the establishment of free drainage. The entrance wound through the tissues will usually be found to be infected, and measures to combat this have to be resorted to. If the original wound is not large enough to allow the free escape of urine from the bladder it must be incised, opened up freely and cleansed thoroughly, and free drainage of the bladder established. If this is impracticable, owing to the difficulty of access to the wound, perineal section should be done at once. This procedure has the advantage of establishing free drainage, of allowing the original wound to granulate and heal up, and of permitting the operator to examine the bladder and of removing any foreign bodies which may have been carried into the viscus at the time of the injury. This wound usually heals without any trouble. If the original wound is ample enough to allow free drainage from the bladder, ordinary cleanliness and attention to the wound plus a retention catheter or regular emptying of the bladder every few hours by means of the catheter will suffice. One of the best measures for combating extensive sloughing and gangrene is to be found in the con-

tinuous bath at a steady temperature of about 100° F. Some remarkable results were obtained from this method of treatment in the author's experience.

The wound usually closes without difficulty and normal micturition is established in a few days. Sewing up of the wound practically never has to be resorted to.

RUPTURE OF THE BLADDER.

In contradistinction to wounds of the bladder we find in the literature numerous reports of cases of rupture of this organ. Ruptures of the bladder may be extraperitoneal, intraperitoneal, or subperitoneal in variety, the latter when the mucous and muscular coats of the organ are only involved, the urine diffusing under the peritoneal investment.

Etiology.—*Predisposing Causes.*—Men are very much more liable to this affection than women. Nearly 90 per cent. of the recorded cases have occurred in men. The condition is most common during the most active period in life, between the ages of twenty and forty. It is rare in children. Of Galaktionow's[5] 15 cases, 5 were about thirty, 5 about forty, 3 about fifty, and 2 about sixty years of age. Besley reported a case in a child of three, and King recorded the accident in a fetus with imperforate urethra (Da Costa[2]).

All authors dwell upon the social milieu from which these cases are gleaned. One of the most important predisposing causes of this condition is drunkenness, and a very large number of the recorded cases of rupture of the bladder occurred in the intoxicated state. This was the case in nearly one-third of the cases reported by Bartels,[1] in 6 out of the 9 traumatic cases reported by Galaktionow,[5] and in the majority of the cases reported by Dobrowolskaja and Wiedemann.[3] Most of the cases reported by the last two authors came to the hospital in an intoxicated state, at times so excited that they had to be put into the delirious wards. This is a very important point, especially if one has to rely upon the patient for the anamnesis.

The importance of intoxication as a predisposing cause to rupture of the bladder cannot be overemphasized, for the neglect of micturition and the diminished reflex activity which go with this state lead to distention of the bladder, and the distended bladder is the highly vulnerable bladder. Drunkards, furthermore, are very prone to become involved in broils and subject to injuries and falls. Distention of the bladder from any cause, such as obstruction to the outflow of the urine from stricture or enlarged prostate predisposes to this injury, for a distended bladder loses its elasticity, rises to a more exposed situation, and is therefore more subject to injury.

Cystitis, ulceration, degeneration, or atony of the coats of the bladder are further predisposing causes.

Exciting Causes.—Traumatism in the strictest sense of the term is the great exciting cause. The trauma may be very slight, indeed, so slight as to sometimes lead to the suspicion of a spontaneous rupture. Galaktionow[5] records a case in which the man insisted that he had drunk some beer, went home and laid down in bed, when he experienced a sudden acute pain in the bladder, etc. The most usual forms of trauma are from lifting of heavy objects, straining at stool, micturition, or during parturition. (Huley reports a case during delivery under anesthesia.) Falls upon the feet, buttocks, or abdomen, direct blows or kicks over the region of the bladder, crushing injuries which may at the same time fracture the pelvis, and the passage of wagon wheels over the lower abdominal region have likewise caused the injury. The injury has been caused by surgical instruments and by the forceful injection of fluids into the bladder.

In 5 of Galaktionow's[5] patients who were in an intoxicated state no trauma could be established.

The most common site of the rupture is in the posterosuperior portion of the bladder. The reason for this, according to Berndt, lies in the fact that the greater part of the bladder is encircled by a ring of muscles and bones, while the superoposterior part is just covered by peritoneum and adjacent intestines. Wersari has shown that this part of the bladder is weaker than the rest of the organ, owing to the peculiar arrangement of the musculature at this point. Of Galaktionow's[5] 15 cases, 13 occurred at this point.

The shape and size of the tear vary considerably, the size being all the way from 1.5 cm. in length to involvement of the entire posterior wall of the organ.

The mechanism of the rupture is not precisely known. It is likely that trauma, whether from before or behind, increases the pressure on the contents of the bladder, and the latter gives way at a point where there is the least amount of counter-pressure. One or more of the coats of the bladder may be torn at the time of the injury, but the tear usually becomes complete later on. It is important, however, to keep in mind that the patient with an incomplete rupture may go about his business for some time, attending to the duties until the rupture becomes complete and symptoms develop.

A remarkable case of this sort is reported by Sujetinow. The patient, who sustained an incomplete rupture of the bladder from lifting a heavy barrel of cement, continued at his work for nine days, passing clear urine normally, and on the tenth day suddenly experienced a severe pain, with inability to urinate. The rupture was found to be a complete one at operation.

Symptoms and Diagnosis.—*Intraperitoneal Variety.*—The clinical picture of intraperitoneal rupture of the bladder may to advantage be divided into two phases, the first phase covering the period up to about twenty hours after the injury, the later course constituting the second phase.

First phase: While the symptoms here are not always definite, they are usually so in the great majority of instances. Upon the receipt of the injury the patient experiences a more or less severe shock and severe pain in the region of the bladder; painful urination or total inability to void urine in spite of a distressful desire to do so; bloody anuria, *i. e.*, the passage after extreme difficulty of a few drops of clear blood. Along with this go the symptoms of peritoneal irritation, such as severe pain in the hypogastric region and distended and tender abdomen. Nausea and vomiting are rarely present. The initial shock may be so severe as to cause death. In other cases there is extreme collapse, with great helplessness and inability to walk. If the case is seen during this phase of the clinical picture, *i. e.*, within about twenty hours after the receipt of an injury, and especially if a reliable anamnesis is obtainable, the diagnosis should not be difficult. The aid of the catheter may, however, have to be resorted to.

The catheter brings away pure blood or a very slight amount of bloody urine. A more characteristic symptom still is one emphasized particularly by Dobrowolskaja and Wiedemann,[3] namely, the withdrawal of excessive amounts of urine. This is even more diagnostic than anuria. The excessive amount of urine is obtained direct from the abdominal cavity if the catheter happens to be passed through the rent in the bladder direct into the abdominal cavity. In this connection, Rauber's figures of the capacity of the bladder should be kept in mind: 735 c.c. in the male and 680 c.c. in the female.

Blood in the urine is also present in contusion of the bladder and in rupture of the kidneys, as well as in some other pathological conditions of these organs, and is therefore in itself not diagnostic of rupture. On the other hand, the macroscopic appearance of the urine may not show the presence of blood, and it is therefore advisable to make a microscopic examination. In connection with this the making of a white cell count is highly recommended, as it may indicate the degree of peritoneal inflammation. Oehlecker[3] proposes a cryoscopic examination of the blood, claiming that the freezing-point of the blood is lower in these cases (0.36 to 0.66) to become normal again later on.

If the case is seen in the second phase of the clinical picture, *i. e.*, twenty or more hours after the injury, when the acute bladder symptoms have subsided somewhat and the peritonitic symptoms overshadow the picture, the diagnosis of the original condition may become rather difficult. Owing to the presence of the usually sterile urine and blood in the peritoneal cavity there arises an aseptic peritonitis which gives rise to reflex phenomena on the part of the intestines. Moderate degree of distention of the abdomen, abdominal pains, with symptoms of ileus, may supervene, entirely clouding the original condition. If the patient is questioned concerning the onset and course of the disorder he may state that a day or two ago he suddenly took sick with pains in the abdomen, since when he passed neither feces nor gas.

As regards urination, he may state that he was able to pass a few drops of clear urine with difficulty.

Objective examination reveals a moderately distended abdomen, insignificant degree of pain on palpation, which is more severe over the symphysis, absence of peristalsis, tympanitis, except over the dependent portions, with change of note upon change of posture. This picture may be mistaken for a volvulus, and such diagnoses have been made. Still, the moderately distended abdomen, the presence of large quantities of fluid in the abdominal cavity, as well as the absence of vomiting and of severe abdominal pains, contradict this diagnosis. If in addition the anamnesis reveals a trauma and some irregularity of urination, the diagnosis of intraperitoneal rupture may be assumed (Galaktionow[5]). This picture is present when the urine is sterile, which is the case in the majority of instances. If, however, because of some disease of the urinary tract, this is not the case, or if an intraperitoneal rupture is caused by perforation with some object, septic peritonitis is usually the result, with its characteristic symptoms. Vomiting and severe abdominal pain set in, the abdomen becomes very tense, fever, toxemia, and the facies Hippocratica supervene. In case an adhesive peritonitis develops the intestines may become adherent to the bladder and close up the wound, thus preventing the escape of urine into the abdominal cavity, or adhesions may form between the various parts of the intestines and form a reservoir for the urine. If one keeps in mind the fact that so many of these patients are in an intoxicated state at the time they receive the injury, and therefore neither themselves realize the seriousness of the condition nor are able to aid by means of a good anamnesis in making an early diagnosis, and if one, furthermore, remembers how extremely important it is to make an early diagnosis in these cases, it becomes clear why so many authorities recommend an exploratory operation as an aid to the diagnosis. This procedure is preferred by modern authorities to the always dangerous oil and liquid distentions as diagnostic measures, indeed, even to much catheterization. According to Nordmann, peritonitis develops in the majority of cases after catheterization, and Galaktionow urges that catheterization should preferably be performed shortly before operation. Alexander considers gaseous distention unreliable, and claims that it adds to shock and disseminates infection. His rule, according to Da Costa,[2] is the wisest to follow; that is, in a case of suspected rupture of the bladder make a suprapubic incision and inspect the prevesical space for signs of extraperitoneal rupture. If extraperitoneal rupture is not found, open the belly and explore.

Extraperitoneal Rupture.—Subjective symptoms are the same, with the exception of those arising from peritonitis. Objectively, there is found swelling and dulness over the symphysis, and if extravasation and infiltration take place, that train of symptoms which goes with

this, and which we have already discussed in connection with sounds of the bladder.

Treatment.—A survey of the mortality rates in this condition in the days before modern surgery and a comparison of these with modern statistics leave no doubt whatever as to the kind of therapeutic procedure to follow in cases of rupture of the bladder.

All of the patients with intraperitoneal rupture reported by Bartels[1] died with the exception of the one operated upon by Walther, of Pittsburgh, a mortality therefore of 99.2 per cent. Of the 373 of extraperitoneal wounds reported by the same author, 85 terminated fatally, a mortality of 22 per cent. These included cases recorded up to 1878. In Evans and Fowler's[4] cases the mortality for the intraperitoneal variety was 28.5 per cent. and for the extraperitoneal variety 11.1 per cent. (1905). Dambin's statistics show a still lower mortality for intraperitoneal varieties, 20 per cent.

The chances of recovery are best in the cases operated upon soon after the injury and decrease in proportion to the time elapsing between the injury and operative interference. This is particularly well illustrated in the 16 patients referred to by Dobrowolskaja and Wiedemann.[3] Six of these were operated upon in the first twenty-four hours. One of these died, giving a mortality of 16 per cent. The remaining 10 patients were operated upon all the way between forty-eight and one hundred and twenty hours after the injury, all of whom died. According to Zuckerkandl, of the 13 patients operated upon in the first twelve hours 8 recovered, and of 21 patients operated later only 6 recovered.

From the above considerations it is obvious that operative procedure is eminently indicated in all cases as soon as the diagnosis is made, and, furthermore, in doubtful cases exploratory incisions may be the best thing for the patient in the end.

The therapeutic indications therefore are (1) immediate laparotomy and exposure of the rent in the peritoneum and the bladder; (2) closure of the wound by sutures; (3) removal of the urine, blood, and foreign bodies from the peritoneal cavity if present. To quote Evans and Fowler:[4] "The obvious advantages of this procedure are: (1) It permits a careful inspection of the bladder and an examination of the peritoneal cavity for extravasation of blood and urine, foreign bodies, and injuries to the intestines. (2) The wounds in the bladder can be tightly closed by sutures, thus preventing the further escape of urine into the abdominal cavity; in other words, to remove the cause of the mischief. Extravasated urine and blood clots can also be removed and a thorough abdominal toilet performed. Injuries to the viscera, when present, may be repaired, thus avoiding the dangers of serious and even fatal complications from this source."

The details of operative procedure will, of course, vary with the individual operator, but there seems to be a preference for doing away

with the drainage tampon in all except those cases which show a diffuse peritonitis. The catheter a demeure should not be left in longer than three days.

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CHAPTER IV.

INFECTIONS OF THE BLADDER.

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CYSTITIS.

It seems fitting in introducing this chapter on infections of the bladder to warn the student and medical practitioner that cystitis as a disease *per se* is extremely rare and that it is usually representative of some coexisting infection either in the upper urinary tract or in the genitals. With our present knowledge of infections in general it is hardly necessary to remark that the majority of inflammations of the bladder are bacterial in origin, nevertheless there are certain inflammatory changes of the viscus which may be produced by chemical or toxic influences. It has been repeatedly and abundantly proved that a normal bladder will resist the invasion of bacteria from its cavity into its walls for a protracted period. This is amply shown by the rarity in which cystitis occurs following catheterization, instrumentation and cystoscopy of the normal bladder. Williams, Murray and Wallace[61] found colon bacilli in 24 of 26 women after operation, yet none of them had cystitis. Lawrason Brown, of Saranac, March 13, 1915, in 104 cases found tubercle bacilli in the urine in 10 per cent., in which there were no evidences of urogenital tuberculosis. These figures agree with Cunningham and Bernstein. It is also a well-established fact that an infection of long duration will often rapidly clear up after the cause has been removed; for example, the removal of prostatic obstructions, foreign bodies or tumors from the bladder and attention to renal and urethral complications. Several fundamental principles are necessary before this invasion becomes manifest.

Our increased knowledge and understanding of bladder infections has been brought about by the modern methods of investigation, such as the cystoscope, ureter catheter, endoscope and modern laboratory technic. By these methods we are able to eliminate many of the old time fallacies and to establish an accurate and scientific diagnosis, so that no longer are all cloudy urines called cystitis.

There has been no generally accepted, clean-cut classification of cystitis. For simplicity and convenience it seems that the following will suffice:

According to etiology	Non-bacterial	Chemical. Mechanical.	
	Bacterial	Acute inflammatory. Chronic inflammatory. Tuberculous. Syphilitic.	
	Yeasts and fungi. Animal parasites.		
According to pathology	Superficial	Localized General	Always acute.
	Interstitial	Granular, cystic, vegetative, hemorrhagic, pseudomembranous, gangrenous, leukoplakia, malakoplakia	Always chronic.
Pericystitis	Suppurative. Sclerosing.		

Non-bacterial Cystitis.—**Etiology.**—Non-bacterial cystitis may be the result of chemical, mechanical, or traumatic influences, which by their presence may create a reaction of the vesical mucosa. Any irritating substance, of sufficient strength and quantity, entering the bladder either from above or through the urethra, may evoke cystitis. Those substances which reach the bladder by way of the kidneys are those which are the natural products of faulty metabolism resulting from individual predisposition, such as the excessive secretion of oxalates, urates, phosphates, cystin, xanthin, and other salts; those which are secreted by the kidneys after having been ingested by the individual, such as cantharides, coal-tar products, balsamics, and urinary antiseptics. Lichenstein and Rehn[39] called attention to the irritating effects on the bladder of coal-tar products. At the present day, owing to its frequent administration, urotropin is a very common cause of bladder irritation. This drug when taken in large quantities for a long period, and in some individuals who possess a susceptibility, even for a very short period, will evoke symptoms of a very pronounced bladder inflammation, characterized by all the ear-marks of a true cystitis. Strong chemicals, particularly bichloride of mercury, nitrate of silver, and caustics, when introduced through the urethra into the bladder, may provoke an intense cystitis. Cases are on record in which the cast of the bladder mucous membrane, and indeed also of the musculature, as in the case of Begouin,[4] have been evacuated after strong chemical injections.

Treatment.—Such inflammatory changes in the bladder are usually transitory, with the exception of those due to faulty metabolism; these require appropriate dietetic and hygienic measures for their relief. Cystitis due to irritants, ingested or directly applied to the bladder, is usually promptly cured by the removal of these substances and the administration of mild sedatives and large quantities of water.

Mechanical Cystitis.—The presence of phosphates, urates, oxalates and other crystals, which were mentioned as factors in the production of chemical cystitis, may also be classed as mechanical factors in the production of inflammatory changes in the bladder. Other common causes are foreign bodies, stones, tumors, and cysts of the bladder; various pelvic abnormalities, such as uterine, tubal, and ovarian displacements; rough instrumentation, and retention of urine with its accompanying circulatory changes.

Treatment.—In order to cure an inflammatory process of this type it is necessary to remove the mechanical influences and to dilute the urine by an abundance of water.

Bacterial Cystitis.—As previously mentioned, the normal bladder will resist bacterial invasion for a long time, and in order for a cystitis to develop, certain predisposing causes are necessary to prepare the soil for such invasion. The three most important predisposing factors are traumatism, congestion and retention.

The influence of traumatism is particularly seen in the action of foreign bodies and tumors of the bladder, and following instrumentation and injury to the bladder wall during surgical operation, particularly hysterectomy, when stripping the cervix from the bladder. The frequent bladder infections which were formerly seen following these surgical manipulations, and which were attributed to catheterization, are now explained by the resulting trauma to the bladder wall, whereby its resistance is lowered to any bacterial invasion which may have been carried in with the catheter. Other important traumatic injuries to the bladder which predispose it to infections are those secondary to pelvic fractures and those due to pressure of the fetal head and instrumentation during delivery.

Congestion of the bladder, which may predispose to bacterial infection by lowering its resistance, may be due to a multitude of circumstances; among the more common may be mentioned exposure to cold, dampness, saturation of the urine with various salts, excretion of various chemicals, excessive venery, and alcoholism and the proximity to the bladder of various pelvic and rectal abnormalities.

Retention is the most important predisposing cause of cystitis. The constant presence of urine in the bladder, acting as an excellent medium for bacterial growth, is indeed an invitation for bacteria to enter, and it is quite rare to see a residual urine live to a ripe old age without having infection as a companion. The common causes of this retention are: obstruction from prostatic adenoma, carcinoma, contraction of the vesical neck and median bar formation; stricture of the urethra; bladder tumor, ureterovesical cyst, when these latter impinge on the internal orifice; tabes and various spinal cord diseases; diverticula. In women, residual urine is occasionally observed in cases of uterine growths, particularly those of the anterior wall of the fundus and cervix, and in bladder sagging due to cystocele.

The active or exciting cause of cystitis is the presence of bacteria.

Pasteur, in 1859, was the first to lay the cause of ammoniacal urinary disorders to bacteria in urine which he obtained by means of catheterization. Traube, in 1864, made a clinical observation as to the etiology of cystitis. Miquel, in 1879, first described an anaërobic spore-forming bacillus which he identified as the cause of cystitis. A streptococcus bacillus was observed by Bouchard, in 1883, and different microörganisms were described by von Jaksch, in 1881, Billet, in 1885, and Limbeck, in 1887. Bumm, in 1886, in 8 cases of puerperal cystitis found a gonococcus-like organism in an acid urine, which he identified as the Staphylococcus aureus. The most important contributions to the subject since that time have been given by Rovsing,[55] in 1890, Melchior,[44] in 1897, Tanago,[60] in 1900, Ritter, Faltin,[15] Baisch,[2] Brown,[6] Raskai,[52] Jungano and Tanaka.[61] A most important finding of many of these observers is that the colon bacillus is the common offender. Many observers have described odd-named bacilli, which have since been identified as the colon bacillus. In 1902 Hartmann and Roger[27] called attention to anaërobic bacilli in cystitis and reported streptobacillus, fusiforms, Micrococcus fetidus, Bacillus ramosis, and the Staphylococcus parvulus. These were found alone or in association with other bacteria; Motz and Le Noir and Barth and Michaux found the pyocyaneus.

The bacteria which are most frequently found in cystitis are the colon bacillus, tubercle bacillus, typhoid bacillus, Bacillus pyocyaneus, proteus bacillus, Bacillus lactis aërogenes; staphylococcus, gonococcus, streptococcus, and the Micrococcus ureæ. Of this group by far the most frequent organisms are the colon bacillus and the staphylococcus. These may occur alone or in association with other organisms. It is very common indeed to see a colon engrafted on tuberculous infections.

Of these bacteria, the colon, tubercle, and typhoid bacilli and the gonococcus are usually associated with an acid cystitis, whereas the staphylococcus, streptococcus, and proteus group are generally with an alkaline. It has been observed that most of the acute infections of the bladder are coccal and the chronic are bacillary. Another observation which Tanaka reports is that the coccus possesses more tendency to produce an ascending infection. Faltin,[15] in his study of bacteria of bladder infections, calls particular attention to the polymicrobic nature of these infections, and also to the liability of change of the bacterial flora. He mentions Maxwell and Clarke, in 1898, as being the first observers to notice this change. Rovsing reports colon infections following initial staphylococcus infections. Pasteur and Lewin noticed that after treating a colon cystitis for two weeks they recovered a pure proteus.

Paths of Infection.—Bacteria may gain entrance to the urinary bladder by way of the urethra—ascending invasion; by way of the kidneys—descending invasion; by extension from a neighboring focus—invasion by contiguity; and by means of the circulation. The early

observers attributed all of the infections of the bladder to extension from the urethra, until Rovsing, Michaux, and Bastianelli recognized the importance of the kidneys as a factor in such infections. This was confirmed by La Grain and Halle.

Ascending invasion may occur, as a result of instrumentation, by the extension of a urethral inflammation or by a direct ascension of the normal urethral bacteria. In well-organized clinics and in the offices of trained urologists, bladder infections following instrumentation are fortunately exceedingly rare, but our experience leads us to believe that among the general practitioners where scrupulous measures are not so ardently observed this fortunate circumstance does not prevail. The important factors in the prevention of posterior urethral and vesical infections following instrumentation are gentleness, care, and cleanliness in instrumental manipulations. Thorough cleansing of the meatus and anterior urethra is extremely important, as the organisms which are present as saprophytes in this portion of the canal may assume a pathogenic disposition when made to enter the posterior urethra. This is accomplished by swabbing the meatus thoroughly with an antiseptic solution and irrigating the anterior urethra with a copious amount of mild antiseptic solution. Following this the bladder should be filled, unless one is passing a catheter for the determination of residual urine. By filling the bladder with an antiseptic solution its walls are spared from trauma, and the patient by passing out the bladder content following instrumentation may rid himself of bacteria which may have been inserted. In any instrumentation, absolute gentleness is necessary. Keyes has remarked that "the cleaner you are the better, but the gentler you are the best."

Extension of an infection to the bladder from the urethra is observed in gonorrhea and stricture, and in inflammatory diseases of the prostate and seminal vesicles.

Whether or not the normal bacterial flora of the urethra possesses the power of entering the bladder against the urinary stream remains undecided. Polladino Blandini, by putting certain bacteria in the meatus of guinea-pigs, found them in the kidneys within twenty-four to forty-eight hours. These experiments are extremely suggestive, but have not as yet been generally confirmed.

Descending Invasion.—Since the advent of the cystoscope, ureter catheter, and the more thorough and scientific investigation of the urinary tract, urologists are finding more and more that bladder infections are secondary to renal disease, such as pyelitis, pyelonephritis, pyonephrosis, either simple or associated with calculus, and tuberculosis. It is not uncommon to see patients who have been treated for supposed chronic posterior urethral infection for months, and indeed for years, and finally to have it discovered that the infection is renal in origin. In this connection we wish to make a plea to the medical profession not to treat lingering urinary infections indefinitely, and if a cystitis does not rapidly respond to the usual routine

measures, to promptly submit their patients to a thorough investigation. By so doing, severe and destructive infections of the important urogenital structures may be obviated. Smith,[56] of Boston, showed that in 87 cases of cystitis which he studied in women, 80 per cent. were associated with renal infection. This observation is sufficient to convince the profession of the frequent association of renal infection with bladder disease. Infections from the kidney involve the bladder by means of the urinary stream, also by direct parietal descent along the ureter, as is seen in tuberculosis.

Extension by Contiguity.—Extension of inflammation to the bladder is occasionally observed as a complication of pelvic and intestinal diseases. It is not uncommon, in fact it is quite frequent, in pelvic inflammatory disease to have an associated involvement of the bladder. This process of extension may also follow appendicular and sigmoidal inflammation, which may erupt into the bladder and form a fistulous communication between the two viscera, producing enterovesical fistulæ, with an accompanying progressive cystitis. Migratory foreign bodies occasionally cause inflammatory extension from one organ to the other. There is a case on record of a pin uniting the appendix and the bladder, producing a severe cystitis, which was relieved by the removal of this foreign body.

Invasion from the Circulation.—There are but a few observers who believe in direct involvement of the bladder by means of the blood stream. Van Calcar[62] is the principal contender of this path of invasion. The vast majority oppose to his view the belief that bladder infections come down from the kidneys, which are hematogenously involved.

Pathology.—The inflammatory reactions of the bladder vary considerably with the character and stage of the infection and with other affiliated pathological conditions. The symptoms may be general or local, more commonly localized around the neck of the bladder and trigone, and in the male there is almost invariably associated with this process an inflammatory reaction in the posterior urethra. According to duration, cystitis may be classified as acute or superficial and chronic or interstitial. With the chronic interstitial form there is usually an accompanying pericystitis.

ACUTE CYSTITIS.—The pathological study of the acute cystitis has been somewhat scarce, owing to difficulty in securing autopsy and surgical material. The appearance of the mucous membrane is one of congestion and redness, which may be generalized, but is more frequently confined around the trigone and vesical neck. One sees markedly dilated vessels with fine arborizations on the surface. The mucous membrane is markedly swollen, its glistening shiny aspect is lost—it is frequently thrown into folds and elevations, the extremities of which are often the seat of hemorrhages and erosions (Fig. 29). In very acute cases one may see deposits of fibrin which may hang from the bladder wall. In bladders with cellules and trabeculations such

lesions are more marked on the boundaries of the cellules and on the summits of trabeculations. This inflammatory reaction is confined to the mucosa and submucosa. Motz and Denis[46] have shown in contradistinction to most authors that the musculature is not involved by inflammatory productions. The bladder musculature, however, is thickened and hypertrophied, owing to overwork produced by vesical irritability. The cavity is diminished, owing to the thickened wall.

FIG. 28.—Acute cystitis showing ecchymoses.

Histoicgical Picture, Epithelium.—Most histological reports are that the epithelium is disintegrated and exfoliated, but in a study of forty bladders Motz and Denis found that the epithelium had preserved its characteristics. They believe that the changes described are postmortem consequences, and that there is no exfoliative change in the epithelium of acute cystitis. The changes in the mucosa and submucosa depend upon the character and duration of the infection. In very mild cases the process may be entirely superficial, with swelling and edema of the epithelium and with desquamation of the superficial cells. At a later period the mucosa becomes infiltrated with leuko-

cytes and traversed by numerous dilated bloodvessels. In the early stages the submucosa may show no changes. As the process progresses the submucosa becomes invaded by vascular dilatations and engorged with blood, and may be studded with scattered collections of leukocytes, producing minute superficial abscesses. This process is entirely limited to the submucosa; the musculature is not involved, the submucosa being freely movable over it. In later stages of acute cystitis the musculature may show hypertrophy, but no inflammatory changes are evident. In very acute infections the inflammatory exudate may form numerous vesicle-like elevations producing the condition commonly known as bullous edema, which is particularly common around the bladder orifice. The abscesses above described may rupture and produce ulceration. The presence of mucopus adherent to the inflammatory areas may give the appearance of pseudomembranes.

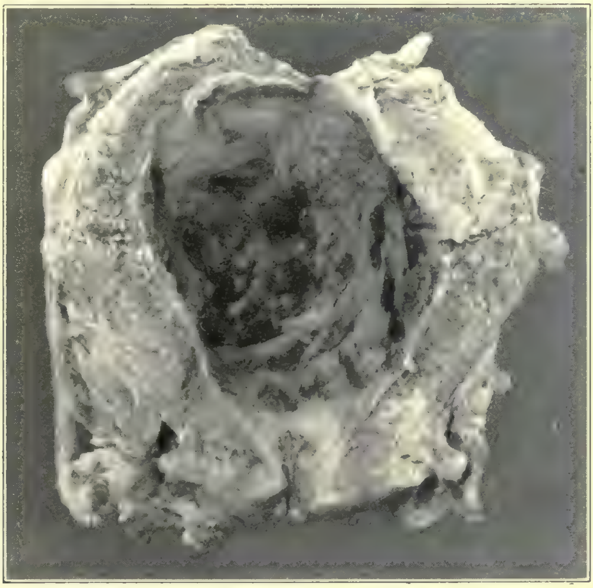


FIG. 29.—Chronic cystitis with submucous hemorrhages.

In most of the standard urological text-books we read of catarrhal cystitis. As catarrhal inflammations are seen only in the presence of glandular structures it is believed that this term should be stricken from the pathology of bladder inflammations, excepting perhaps in case of the persistence of glands or in case of infolding of the mucous membrane with the formation of pseudocysts.

CHRONIC CYSTITIS.—The pathology of a chronically inflamed bladder is extremely variegated. The most comprehensive study of this chapter has been given by Stoerk and Zuckerkandl[58] and Halle and Motz.[23]

The picture may be pure or complicated (Fig. 30), the latter depending upon mechanical obstructions, such as those associated with prostatic or stricture obstructions, or those due to nerve influences, to tumors, foreign bodies, stones, etc. Chronic cystitis is always interstitial. In the pure and uncomplicated form the bladder capacity is restricted and its form is altered so that it is no longer capable of undergoing its normal distention. The internal surface presents kaleidoscopic appearances: the wall is thickened and transformed and there is practically always an associated inflammatory reaction in the pericystic tissues. The bladder capacity is always more or less lessened, depending naturally upon the age and the character of the inflamma-

Fig. 30.—Chronic cystitis as result of prostatic obstruction and vesical diverticulum.

tion. In extreme cases it may be reduced to thimble size. Its form and position may be materially altered, owing to a symmetrical contraction; in pronounced cases the bladder may be tucked snugly up against the symphysis pubis. The wall is always thickened, in some cases to the extent of several centimeters, and as a result of this thickening diminution in capacity occurs. All the coats are invaded by inflammatory changes, so that they no longer move freely over each other. This change is more marked in the submucosa.

Changes in the Mucous Membrane.—The mucous membrane loses its uniform salmon-pink color and its smooth regular aspect. It becomes paler, slate-colored and mottled, this mottling being due to vascular

ecchymoses, seen more commonly around the trigone and ureteral orifices. Scattered among these old pigmentations may be observed bright red areas, which are due to vascular arborizations, which occur usually in patches. The mucous membrane loses its smooth, regular appearance and there are formed irregular, bullous elevations, villous projections and papillary elevations extending above the surface—granular cystitis. This granular condition occurs usually in plaques, but may involve the whole bladder. Should these granulations proliferate, as they occasionally do, they may assume enormous sizes, and produce the so-called vegetative cystitis. These vegetations may occur as large papillary projections arranged in groups resting upon the folds of the mucous membrane, deep red in color owing to their great vascularity, varying in size from a pin-head to the size of a pea. Again they may be short, thick and sessile, soft and fungus-like and very bloody; they may occur with long thick pedicles and give the appearance of a papilloma. Their color is extremely variable, from pale rose to black, the latter due to hemorrhages. Another lesion occasionally seen in chronic cystitis, is the one described by Dogiel,[12] Rokitansky,[54] Klebs,[33] and Limbeck,[40] namely: cystitis cystica, which is due to a downward proliferation of the epithelium forming pseudo glands, which, if secreting, cause cysts which will be visible on the surface of the mucous membrane. This has been more recently studied by Zuckerkandl. As this condition is seen also in bladders which are not the seat of inflammatory processes, it is considered by some as not representing inflammatory change.

Histology, Mucous Membrane.—Epithelium is partially or totally desquamated, superficial cells destroyed, epithelium reduced to two or three layers, generally unequal in thickness, irregular and swollen. In severe cases the entire mucous membrane may be exfoliated, and the bladder cavity lined by connective tissue. The deeper layers of epithelium are generally modified, the cells being irregular, polyhedral with large nuclei and granular protoplasm. Under the epithelium are seen inflammatory collections of epithelioid, lymphoid and connective-tissue cells. By this proliferation, the mucous membrane may be elevated into papillary projections. In this new formed connective tissue there are usually large dilated bloodvessels, filled with blood; in older lesions this connective tissue gives place to the organized compact fibrous tissue with fusiform cells with but few elastic fibers, producing the dense sclerosis, which is commonly seen in the later stages of chronic cystitis. There are often seen many small interstitial hemorrhages, frequently néar the surface. In the deep layers, if hemorrhages occur between the compact bundles, they may cause necrosis by pressure. These hemorrhages are particularly common in vegetative cystitis. Small microscopic abscesses are commonly seen along the bloodvessels; it is to the breaking down of these small abscesses that multiple ulcers may ensue.

In vegetative cystitis the essential lesion is an exuberant granula-

tion tissue rich in bloodvessels, and generally covered by epithelium, producing villous projections. As was said, the epithelium is seldom present; there are certain types, however, in which the epithelium proliferates and produces either a papillary projection, or the growth downward into the mucous membrane with the formation of cysts or leukoplakial plaques. The cystic type, so-called cystitis cystica, which was described by Dogiel, is a result of an epithelial growth downward, with glanduliform inclusions, which become isolated and undergo degeneration and cystic formation, although Zuckerkandl claims that there is not cystic degeneration, but that the cystic quality is due to the assumption of secretory activity on the part of the epithelium. This author believes that this type of cystitis is the precursor of carcinoma. The various degrees of evolution from the initial budding off of the epithelium to the final cystic production can be observed.

The Submucosa.—In chronic cystitis the submucosa loses its flexibility and softness and fuses with the muscles and mucous membrane. It is replaced by dense connective tissue and dilated bloodvessels which cause its fusion with the other layers.

Musculature.—In the early stages of chronic cystitis, the musculature is hypertrophied owing to overwork from frequent bladder evacuations. The late and common lesion of the musculature is one of connective-tissue invasion. There is generally marked proliferation of the interfascicular connective tissue, causing an enormous increase in the thickness of the bladder wall; later on the process may involve the muscle bundles themselves in an intrafascicular sclerosis with the production of a musculature atrophy. Granular and hyaline degeneration are frequent and acute myositis is occasionally encountered.

Complicated Chronic Cystitis.—The pathology of complicated chronic cystitis so far as histology is concerned is identical with the simple. Its gross changes, however, vary according to the associated superimposed pathological lesion, whether it be an extensively trabeculated or celluled or diverticulated bladder, or one associated with foreign bodies, tumors or lesions representative of spinal cord disease.

Leukoplakia and Malakaplakia.—In these constructive lesions of the bladder mucous membrane there is a transformation from the normal to that of the cornified epidermis. These lesions have been given numerous names, such as, leukoplasia, leukoplakia (Schwimmer), xerosis (Leber, Förster), malakoplakia (Hansemann), cholesteatoma, (Rokintansky), pachydermie (Virchow), psoriasis membrane mucosæ, leukokeratosis (Le Dentu), and musculæ lacteæ. These names represent one and the same process of epithelial proliferation and keratinization. These lesions are quite rare and have been described for a long time. English,[14] in 1907, presented a complete review of this subject. He mentioned but 27 cases of leukoplakial bladders. This peculiar bladder lesion is observed in the course of certain cases of chronic cystitis; tuberculosis is supposed to be an important etiological factor,

as is also gonorrhea. Stones and foreign bodies add their share to the etiology of these plaques. The process occurs usually as isolated multiple plaques, sharply contrasted from the otherwise inflamed mucous membrane by their light color, their parchment-like consistency and their smooth surfaces. The borders are clean cut and very adherent to the bladder. The process, may, however, invade the entire mucous membrane (Ravasini). Sometimes these plaques undergo calcification; villous projections are occasionally encountered; ulceration has also been observed.

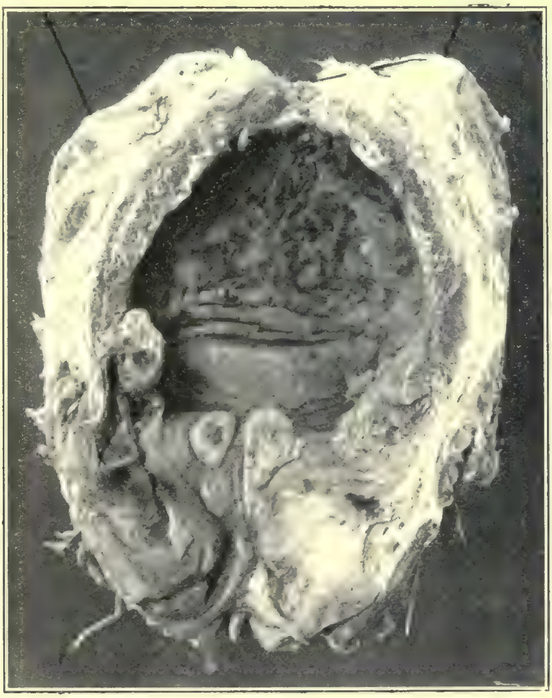


FIG. 31.—Chronic cystitis, pseudomembrane formation.

Malakoplakia, named by Hansemann,[25] a lesion belonging to this group, is characterized by elevated, yellow plaques, formed of proliferated epithelium. At times these lesions resemble condylomata and pedicle formation is occasionally observed in all these varieties. The exact nature of the lesion is unknown. There is considerable epithelial desquamation. Ikeda,[30] calls attention to the presence of glycogen in the leukoplakial cells. These lesions may be the precursor of carcinoma.

The destructive forms of chronic cystitis are: pseudomembranous, ulcerative and gangrenous.

Pseudomembranous cystitis occurs in two forms (Fig. 31), either in

the disseminated circumscribed plaques, or confluent exudates covering the whole of the surface of the mucous membrane. These pseudomembranes are of a dirty, gray color, composed of fibrin, débris, leukocytes and bacteria; they are soft, slightly elevated and adherent to the mucous membrane. Their free borders are very irregular and ragged. When the membrane becomes old, it loosens in places and

FIG. 32.—Gangrenous cystitis. Carcinoma of the bladder with rupture and suppurative pericystitis.

hangs as shreds from the bladder wall; it may become entirely detached and pass off through the urine; it may become infiltrated with lime salts. If the process is more pronounced there is a superficial necrosis and a deep chronic inflammatory infiltration. After prolonged pressure during a protracted labor, or following very severe bladder infection, there may result a death of the whole bladder wall,

so called gangrenous cystitis (Fig. 32). The most complete works on this subject are those of Halle and Motz,[23] O'Neil,[48] Guinard,[22] Prigl,[51] Stoeckel,[57] Mezard.[45]

A frequent complication of any of these severe forms of cystitis is ulceration. These ulcerations may be single or multiple, located in different parts of the bladder, more commonly around the trigone; they may be superficial or deep—the superficial ulcerations of the bladder are the common ulcerations which are seen; the true or deep ulcerations are rare, and are believed to represent some trophic disturbance of the wall, rather than a part of a chronic inflammation. These destructive, pathological processes differ in no essential manner from the other destructive inflammatory lesions of the bladder. The terrific bladder destructions may proceed to such an extent that the whole bladder mucous membrane, indeed with a great part of the bladder musculature, may be destroyed by necrosis, the so-called necrotic or gangrenous cystitis. An interesting case which recently occurred in the writer's experience was that of a chronic fulminating ammoniacal cystitis, associated with carcinoma of the bladder, in which the whole bladder mucosa and submucosa were necrotic, resembling soft mud. The patient died from a suppurative pericystitis with general peritonitis due to rupture of the bladder at the site of the carcinoma. Such severe inflammations are seen following caustic injections into the bladder, as in the case of Guinard, in which the patient had attempted abortion. It is also seen in women during the early months of pregnancy associated with a retroflexed uterus. Kidney infections are very common with this type of bladder infection. Other contributors to this important subject have been Boldt,[5] and Krukenberg.[35]

The histological picture of the destructive lesions, pseudomembranous, ulcerative and gangrenous is the following: the mucous membrane is deprived of its epithelium and lies in contact with the infected urine; there is a superficial necrotic zone composed of fibrin, pus and bacteria, forming a pseudomembrane. In the pseudomembranous type there is generally a superficial necrosis of the mucous membrane, and a plastic exudate of fibrin and pus attached to it. Lime salt infiltration is common. When these pseudomembranes detach, an ulcer is left. In the gangrenous form the whole bladder wall may be involved, even the peritoneum, as in the case of Haultain.[28]

The Microscopic Examination of the Mucous Membrane.—The mucosa and submucosa are involved by a general necrosis and are often unrecognizable. In the muscle coats the fibers are swollen, the nuclei are small and show very poor staining qualities. The vessels are engorged with granular contents, these changes result in coagulation and hyaline necrosis, secondary to extreme congestion of the bloodvessels.

Symptoms.—As the symptoms of acute and chronic cystitis are extremely hard to differentiate clinically, they will be considered together. The cardinal symptoms are: frequency, pain and pyuria.

The one which is always constant is pyuria, without it there is not cystitis. The quantity of pus in the urine depends upon the intensity, duration and character of the infection. It is constantly present without variation, unlike the pyuria of renal origin.

Frequency of Urination.—Frequency of urination is usually the first symptom which attracts the patient's attention to the disease, it being more frequent in the daytime than at night, and in severe infections the patient may have a constant desire to urinate, having to evacuate the bladder as frequently as five-minute intervals. This is particularly seen in the severe types of chronic cystitis. Frequency is worse on motion and in the upright position, as the urine gravitates to the inflamed vesical orifice.

Pain.—The pain of cystitis is inconstant and variable. It may precede, accompany or follow micturition, more commonly it follows it. The pain and frequency of cystitis are often due to associated lesions, such as prostatitis, posterior urethritis and foreign bodies.

Other symptoms which are observed in cystitis are pain of a bearing-down character in the lower abdomen, suprapubic region, perineum and rectum, although in the male these may result from an accompanying posterior urethral inflammation.

Hematuria is frequently observed in cystitis, it is seldom pronounced, amounting at most to a smoky urine, usually it is terminal, consisting of a few drops of pure blood at the end of the act. Fever and constitutional symptoms do not result from cystitis itself, but usually from a coexisting infection either in the upper urinary tract or prostate and vesicles. Retention of urine resulting from cystitis is rare. The urine of cystitis may be acid or alkaline in reaction. Acid cystitis is usually milder than alkaline, unless it is tuberculous. Though the symptoms are usually milder in acid cystitis, it is quite intractable unless the cause is removed, such as an obstrucing prostate, stricture, foreign body or an infected kidney. Alkaline cystitis is usually severe and serious, urination is very frequent and painful, the urine extremely dirty and foul and frequently contains calcareous material.

Gangrenous Cystitis.—The symptoms are those of a severe aggravated cystitis, associated with very dirty, foul-smelling ammoniacal urine, frequently containing particles of the necrotic membrane. Paradoxical incontinence and retention are common. One characteristic observation which has been noticed in many cases of gangrenous cystitis has been the inability to evacuate the bladder with a catheter, owing to occlusion of the catheter with the exfoliated membrane. Pyelonephritis is commonly seen with this type of disease, and owing to its presence it usually produces in the individuals severe constitutional symptoms.

Leukoplakia is represented by symptoms which are those of a protracted chronic cystitis. One symptom of importance is hematuria which is often abundant, simulating the bleeding of neoplasm, with which it is sometimes confounded. The symptoms are rebellious and

resist medication. Pain is seldom present. A characteristic finding is that the urinary sediment contains a large amount of cornified epithelial cells. These cells occur in large masses, and may be of extreme diagnostic value; glycogen has been found in them, but has never been demonstrated in the urine of these patients.

Diagnosis.—The diagnosis of cystitis is frequently based upon its symptoms, namely: frequency, pain, and pus in the urine. These, however, are entirely insufficient, and this superficial diagnosis is responsible for many of the destructive kidney lesions. The profession must realize that if such symptoms do not promptly abate under the standard treatment for cystitis, within a week or ten days, the cystitis is complicated by some other disease, particularly infections in the kidney. I know of no other term in urology which is more abused than the much overworked cystitis. It must be repeated that infected urines do not represent cystitis until infections of the other genito-urinary organs have been ruled out by a thorough and scientific investigation. With our present up-to-date facilities for arriving at a prompt, clean-cut, accurate diagnosis of urinary disease, it seems nothing less than a crime that so many individuals are subjected to blind therapy.

How are we to arrive at the diagnosis of cystitis? In the first place the history is of service only in attracting us to the fact that the patient has vesical symptoms. The individual may have these symptoms and still not have cystitis, but these give us a lead to direct our attention to this viscus.

The method of direct examination consists in the following: general inspection, palpation, cystoscopy and ureter catheterization. General inspection is usually of little service in differentiating a true from a complicated cystitis, or even in helping us to lay any claim to the diagnosis of cystitis at all, except in cases where there is evidence of some gross abnormality, such as a mass in the renal or suprapubic regions or urethral discharge. Watching the patient void may be helpful in showing the facial expression of pain so frequently associated with the passage of the urine.

Palpation may be of great help. One may be able to elicit suprapubic tenderness and muscle spasm or even to feel a thickening in the suprapubic region in some of the severe types of chronic cystitis associated with perivesical inflammation. We also may be able to palpate vaginally or rectally a thickened bladder or ureters, but in ordinary, simple bladder inflammations, such examinations are of little service.

We must depend chiefly, and indeed entirely upon the cystoscope and ureter catheter to lead us to the proper diagnosis. Before discussing the cystoscopic appearances of cystitis, it may be well to mention a few points with reference to the urinary examination. The urine of cystitis is cloudy in all three glasses when voided or catheterized, and it is essential to have the patient void, or be catheterized into two or three glasses. In the female a voided specimen is

often misleading, for I have seen many cases of supposed cystitis, in women who had vesical symptoms, with a cloudy urine, which was due to urethral secretions. It is also important to catheterize the female into two or three glasses, for the reason that often in chronic urethritis with considerable exudate, the first glass may contain pus and bacteria and the second be entirely clear and sparkling, so that if one were to catheterize and receive the urine in one glass alone, the centrifugalized urine would frequently contain pus and bacteria which came from the urethra and give one the impression of cystitis. While in the older text-books on urology, much stress was laid on the character of urinary sediment and of the microscopic appearances of the cellular content, the writer is willing to admit his entire inability to place any dependence on either the character of the sediment or of the microscopic appearance of the pus cells, or of the epithelium, as to whether they come from bladder or kidney. The bladder urine must be thoroughly examined microscopically for pus, blood, crystals, epithelium and bacteria; also for the reaction, specific gravity and albumin content, in order to compare it to the urine from the kidney in case of ureter catheterization. T. R. Brown has shown that in cystitis the albumin usually forms a small delicate ring with nitric acid, and that in kidney disease a well-defined ring is noticed. This brings us to the absolute and important means of diagnosing cystitis.

Cystoscopic Examination.—In undertaking a cystoscopic examination it is always essential, first, to determine if there is residual urine, as this would give a clue to retention as a factor in the production of cystitis. The determination of the bladder capacity is of extreme importance in revealing the amount of inflammatory change which the bladder has undergone, or the irritability which it suffers through the inflammation. This being done, we now attempt by actual vision to determine the pathological process which is present. A few words as to the cystoscopic appearance of the normal bladder mucous membrane: the internal sphincter is generally smooth and regular, deep red in color nearer the bladder wall, but at its margin it is paler than the rest of the bladder, and in fact it is almost white. This statement is a bit different from that made in the ordinary standard text-books, but by careful observation in many cases this white rim has been universally present. The trigone which normally stands out from the rest of the bladder mucous membrane by its more pronounced vascularization, is much more deeply red than the rest of the bladder wall which is of a pale salmon-pink color, in the midst of which are seen fine, ramifying, delicate vessels. Another omnipresent normal finding in any bladder is the air bubble at the dome, which shows a glistening conglomeration of electric bulbs. The reason that this is mentioned is to warn the novice, who is so frequently prone to call it a bladder ulcer or cyst. The ureteral orifices appear clean-cut and smooth and are seen to undergo normal contraction and retraction with the ejaculation of urine.

Acute Cystitis.—The most characteristic cystoscopic finding in cystitis is the disappearance of the normal vascular network and its replacement by a diffuse redness due to hyperemia. Later there is a roughened, uneven angry appearance due to the accompanying edema. This process may involve the whole bladder or may be localized in one or more points on the bladder wall, more commonly around the internal orifice and trigone. Over this angry, reddened wall may be seen patches of adherent fibrin and mucopus, which appear as whitish shreds. There may be interspersed areas of ecchymoses, petechial whorls, and ulcers. These ulcers are usually yellowish white in their centre, of linear outline, and surrounded by an intense red hyperemic zone. Ureteral orifices may be edematous, but usually show no localized intense process in an uncomplicated cystitis. Should they be ulcerated, retracted, scarred or materially changed a renal involvement may be predicted. Very frequently in an intense cystitis the edema is so marked on the trigone, particularly the anterior part and around the floor of the internal orifice, as to produce a bullous edema.

In acute gonorrheal cystitis the process is usually limited to the trigone and bladder neck, seldom involving the general bladder wall. The inflammatory reaction is usually intense. The trigone is generally beefy red, very granular, edematous in places, and often shows ragged excrescences.

In acute cystitis accompanying foreign bodies, stones, tumors, stricture, prostatic obstruction, and obstruction due to spinal cord disease, and in bladders whose walls are trabeculated or show diverticula, the cystoscopic appearance is similar to that in simple cystitis, with the exception of the presence of such complications. In trabeculated bladders the most intense reaction is observed on the summits of the trabeculations; in acute diverticulitis and in enterovesical fistula the inflammatory reaction is more intense directly around the openings. In case of incrusted cystitis, which will be taken up more fully under a separate heading, the picture is modified by the silvery-white granular deposits.

Chronic Cystitis.—In the diagnosis of chronic cystitis we are frequently assisted by a history of bladder distress extending over a considerable period of time. Periods of remission may have occurred, but usually the symptoms have never been entirely quiescent. In some cases, however, the symptoms are of short duration, and our history is of little service in differentiating an acute from a chronic process. The general methods of diagnosis, such as inspection and palpation, are of no more value in the diagnosis of chronic cystitis than of the acute forms of the disease. The cystoscope and ureter catheter are necessary to solve the problem.

Cystoscopic Examination.—The first observation in a chronically inflamed bladder is that it is usually more or less restricted in its capacity. In extreme cases the capacity may be diminished to but a few centimeters. The mucous membrane shows an absence of its normal

salmon-pink color and general smoothness. Ordinarily it shows a slate-colored mottling, due to vascular changes, seen more commonly around the trigone. There may also accompany this dark mottling, patches of bright red, ill-defined areas, due to vascular dilatations. There may be numerous submucous hemorrhages varying in size. In case these predominate and give the bladder an angry red, mottled aspect it is usually described as a hemorrhagic cystitis. The mucous membrane is frequently irregular and granular. It may present bullous swellings, seen particularly around the base of the internal sphincter and upon the anterior part of the trigone. At times these bullous swellings become quite large and resemble true cysts. Owing to granulation tissue with its villous formations and projections the surface may have a granular appearance—so-called granular cystitis. In vegetative cystitis, which is a later stage of this proliferative type, the villi may be of enormous size, occurring in large papillary projections, either singly or in groups, very red and vascular, usually with dilated club-shaped ends, or they may be short and thick. These are often confused with papillomas. Their surfaces are frequently studded with hemorrhages, giving them a dark brown appearance. Knorr has described a lesion which is often observed in chronic cystitis, termed follicular cystitis, which consists of a collection of rounded, elevated, yellowish-gray nodules due to a subepithelial round-cell infiltration and lymph accumulation, with a surrounding deep red zone, closely resembling and frequently indistinguishable from tubercles. In long-standing infections of the bladder, particularly those associated with pelvic disease, there frequently occurs an edema bullosum, which was described by Kolischer.[34] This is a localized involvement of the mucous membrane of the bladder, characterized by the occurrence of clear vesicles, varying in size from a millet seed to a pea; between these vesicles may be seen white floating shreds which are the remnants of some of the ruptured sacs. This type of cystitis is common around the trigone and on parts of the bladder which are adjacent to extravesical inflammatory and malignant conditions.

Cystitis Cystica.—Described pathologically by Limbeck, Rokitansky, Klebbs, Dogiel and Zuckerkandl is a lesion which would be cystoscopically difficult to differentiate from certain types of bullous edema. It occurs as collections of small, round vesicles, either clear or yellow in color, usually of small size, as they have been likened to the individual eggs of caviare, located more commonly around the trigone, but may be scattered in different parts of the bladder mucous membrane. By some these cystic collections are supposed to be representative of inflammatory processes; by others they are thought to occur in perfectly normal bladders.

Ulceration of the Bladder.—Ulcers of various size, shape, and depth are frequently observed in chronic cystitis. Usually, however, such ulcers are more or less superficial. These characteristics of the ulcers, namely: size, shape and depth depend materially, as was shown first

by Fenwick,[16] upon whether the area is stretched or flaccid. With a distended bladder an ulcer may appear as a superficial erosion, and with a bladder only partially distended, the ulcer may present an entirely different appearance and be characterized by piled-up irregular edges, resembling a Hunterian chancre. In the cystoscopic examination of such ulcers one frequently is bothered with bleeding due to tearing of the edges of the ulcer. Ulcers are more commonly observed, as Pasteau has shown, in the bladder fornices, and particularly on the base. The surfaces of the ulcers frequently have floating filaments attached to them. Legueu remarks that the characterization of an ulcer serves less to define its nature than other lesions of the bladder mucous membrane. Causes of bladder ulceration other than those commonly observed in the ordinary forms of chronic cystitis are tuberculosis, typhoid fever, trauma, syphilis, malignancy, and trophic disturbances. The ulcers of tuberculosis, syphilis and solitary ulcers will be discussed in separate paragraphs. The malignant ulcers do not belong to this category of inflammatory lesions. Traumatic ulcers are seen as a result of mechanical, chemical or thermic injury, the commonest of these seen at the present day are the thermic, occurring particularly after high-frequency sparkings to bladder papillomas. These are usually superficial with irregular, yellowish-gray bases, slightly raised, irregular edges with a surrounding hyperemic zone. Typhoid ulcers are extremely rare, usually small and punched out and present the appearance of a typhoid ulcer of the intestinal mucous membrane.

In pseudomembranous cystitis one may see a complicated picture. The process may be confined to certain areas or may cover the whole bladder surface. Generally in an otherwise inflamed bladder mucous membrane one will see areas of dirty, yellowish gray, with edges ragged and floating, around which there is an intense hyperemia. If these plaques are multiple and the pseudomembrane loosens in many places, it may give the appearance of dirty sea weed.

The cystoscopic pictures of gangrenous cystitis have been given us particularly by Norris, Margulies, Stoeckel, O'Neil and Hagner. In the case of Norris the bladder was contracted, the mucous membrane thickened and red, with numerous hemorrhagic areas, the trigone intensely congested, but showed no ulceration. In one of O'Neil's cases, he states that the bladder wall everywhere was fiery red, with masses of shaggy mucous, and nowhere was there a suggestion of normal mucosa; these two observations were made before exfoliation had occurred. Margulies cystoscoped the inside of an exfoliated sac after it had separated from the bladder wall. The surface everywhere was equally dirty, grayish white in color and covered with short hair-like crystalline deposits. In places there were adherent accumulations of pus. He remarked that the surface looked "like a piece of dirty gray skin covered with short hairs." Neither the trigone nor the ureteral orifices could be recognized. He could not interpret his pic-

ture until after operation. Stoeckel describes the appearance of two bladders after exfoliation of the mucous membrane. The bladder wall had an intensely white appearance, ureteral openings large. A case which the author has recently seen in gangrenous cystitis associated with bladder tumor showed a dark, dirty, irregular, shaggy bladder mucous membrane with deposits of mucopus everywhere, with scarcely any bladder features recognizable. A case of Hagner had an entirely black mucous membrane and as he said, had the appearance of gangrenous tissue.

Leukoplakia and Malakoplakia.—These rare lesions appear cystoscopically as multiple white or yellow plaques on an otherwise chronically inflamed bladder, usually smooth and rigid, but may produce papillary prolongations. They are frequently incrusted with salts, the borders are usually well defined. Occasionally they undergo malignant degeneration.

Ureter Catheterization.—In all forms of cystitis, whether acute or chronic, if the infection does not promptly subside with the standard treatment of cystitis, it is essential to employ the ureter catheter in order to determine if the infection is secondary to the upper urinary tract. As the kidneys are responsible for 80 per cent. of such bladder infections, it makes it indeed urgent that they should be investigated. Some authors have advised ureter catheterization in acute cystitis, but with the exception of extremely acute cases where cystoscopy would be particularly trying to the patient, there is no reason why the ureter catheter should not be employed. Untoward results, such as the carrying of the infection from the bladder to the kidney are seldom if ever observed, because infections do not reach the kidneys through the lumen of the ureter, providing the latter is functionating in a normal manner.

Differential Diagnosis.—As the classical symptoms of cystitis, frequency, pain and pus are also the symptoms of other inflammatory lesions of the genito-urinary tract, it is impossible to make the diagnosis of cystitis from them alone. The usual lesions which require differentiation are renal infections; pyelitis, pyelonephritis, pyonephrosis, tuberculosis and renal calculus; prostatic, seminal, vesicular, posterior urethral infections and bacteriuria. There are also diseases which present symptoms of cystitis which are associated with clear urine—chronic posterior urethritis, prostatitis and vesiculitis, trigonitis, or better, trigonal hyperemia with irritability, pollakiuria associated with pregnancy and pelvic tumors, also vesical symptoms associated with cystocele, urethrocele, urethral caruncle and polyps.

Kidney Infections.—Before the days of the cystoscope it was extremely difficult and often impossible to differentiate a true cystitis from one associated with kidney disease unless the kidney process manifested itself by definite symptoms. In case of severe pyelonephritis the old irrigation test proved of service. This consisted in passing a catheter, emptying the patient's bladder, and wash-

ing it clean with solution. Following this the catheter was left in place and the urine collected for a short period. If the urine collected was as dirty as the bladder urine the diagnosis of pyelonephritis was evident. Since the advent of the cystoscope and ureter catheter such a test is seldom used, except by those who do not possess the facilities. There is seldom any difficulty in determining the presence of renal infection, either by single or double ureteral catheterization, although the writer feels that single catheterization is never satisfactory, as one must be always thoroughly acquainted with the exact condition of the supposedly normal kidney, because if there should be infection in one, the most important thing to determine is the exact functional capacity of the sound one. Acute prostatitis and seminal vesiculitis seldom offer difficulty. They usually occur in a course of acute gonorrhea. Rectal examination will reveal the large, swollen, hot, and tender prostate and vesicles. With cystitis this does not obtain. In chronic prostatitis and posterior urethral infections associated with bladder irritability, which irritability really represents posterior urethral irritability, the three-glass test will serve our first means of differentiation, the first glass either being cloudy or clear with shreds; the other two glasses clear. Prostatic and vesical secretion will show varying amounts of pus content. Furthermore, the patient will improve sufficiently after a few treatments, to help stamp the diagnosis. It is a very common occurrence to have the association of renal infection, cystitis, posterior urethritis, and prostatitis, the latter usually promptly clearing up after the renal infection has been removed.

Bacteriuria.—The cloudy urine due to bacteriuria is easily distinguished from a cystitis by the absence of pus in the urine, the haze being due entirely to bacteria. The irritable bladders so frequently seen in women due to trigonal congestion is confused with cystitis. In these the urine is generally clear, unless it is hazed with epithelial flakes, but the symptoms may be typical of a bladder inflammation. The cystoscope tells us the true nature by showing the hyperemic process confined to the trigone, without inflammation of the bladder wall. It is also very common in women to see associated with this complex, chronic urethritis, urethral polyps, producing all the evidence of cystitis, except the purulent urine. These may be diagnosed by means of the endoscope. A very troublesome and annoying affection in women is urethral caruncle, its presence being responsible for distressing symptoms, which would often lead one to suspect a bladder inflammation. The presence of a clear urine and of the unmistakable caruncle at the meatus serves to make the diagnosis probable; the cystoscope will make it absolute. A recent case in the writer's practice gave a typical history of cystitis with frequency and pain coupled with hematuria. Examination showed a large, succulent caruncle which was bleeding and the blood in the urine was due to it; the last urine being entirely clear. The pollakiuria of pregnancy offers but little difficulty in differentiation, as it is expected. The

frequency due to pelvic tumors, particularly fibroids, should offer no obstacles. The urine is clear, one can usually palpate the tumor, and the cystoscope will almost invariably show the bulging in of the bladder wall with shadows or distortion, and there is usually a history suggestive of pelvic disease. Cystoceles so commonly seen in multiparæ, are so self-evident from casual inspection that they offer little difficulty in diagnosis, particularly if the urine is clear.

Prognosis.—Acute cystitis follows one of two courses: it will either rapidly recover spontaneously or by proper treatment or become chronic. Chronic cystitis, if associated with other conditions, such as stone, tumor, and retention, promptly gets well when such predisposing causes are removed. It may get well under treatment, even in the presence of such existing causes, but always shows a marked tendency to recurrence unless such causes are removed. Pericystitis is commonly seen with chronic cystitis, and may assist in producing a rebellious type of bladder inflammation, which may resist all forms of treatment. If the patient's kidneys are not involved there is seldom any danger to the life of the individual.

Treatment.—*Prophylaxis.*—One of the most important missions of the urologist is to protect the urinary tract from infection. During the repeated manipulations on the urogenital tract, unless one is particularly cautious and strict in the observance of the hard-and-fast rules of asepsis and gentleness, one will be extremely liable to have as a result of his neglect an unfortunate series of infected bladders. In treating diseases of the prostate there is great liability to infection unless the strictest care is observed. On the other hand, infection may occur spontaneously, back of prostatic obstruction with an associated residual urine, or in cases of diverticula, stone, tumor, or tabes. Under such conditions our best method of prophylaxis is the removal of such complications. The other alternative would be to exercise great care in the handling of such lesions by local measures, and to instruct the patient to avoid all conditions which would lead to congestion, to observe care in diet and exercise, to keep free from exposure, and pay strict attention to his bowels. Urinary antiseptics and copious amounts of water are usually indicated. In catheterizing individuals for urinary retention, which is so frequently the precursor of cystitis, the anterior urethra should always be irrigated with an antiseptic solution prior to, and the bladder thoroughly washed out following, catheterization. Catheterization must be done with gentleness in order to inflict as little trauma as possible upon the urethra and bladder. The obstructions from tabes and spinal cord diseases, which so frequently require regular catheterization, necessitate a strict following of asepsis.

In the routine treatment of chronic prostatitis and seminal vesiculitis, during the treatment of which infected material is expressed into the posterior urethra and bladder, thorough irrigation with antiseptic solutions should always follow, in order to cleanse the bladder and urethra of this infectious material. In gonorrheal urethritis our

chief aim is the prevention of infection to the posterior urethra and bladder. The treatment of this, however, is detailed under a separate chapter and will not be discussed here. In any urethral or bladder instrumentation these same rules of asepsis and gentleness apply. It is always well before such manipulations to give the patient urinary antiseptics and continue them for several days thereafter.

The treatment of cystitis may be classified as follows:

- Medical
  - Hygienic.
  - Dietetic.
  - Therapeutic
    - General.
    - Local.
- Surgical
  - Removal of cause.
  - Curettage.
  - Cystostomy
    - Suprapubic.
    - Perineal.
  - Vesicovaginal fistula.

ACUTE CYSTITIS.—In acute cystitis, or in acute exacerbations of chronic cystitis, it is important to determine the nature of the infection and of any coexisting complications, although if the disease is hyperacute, the determination of the latter is better left until the symptoms have been quieted. In such acute conditions patients should be quiet, remain in bed and drink large amounts of water, at least a glass an hour. Alkaline waters are preferred by some, but I believe that pure water in large quantities is about as efficacious as any of the bottled waters, which enjoy such happy reputations. The chief thing is to drink water, and more water, in order to render the urine as bland as possible. And it is often observed, unless cases are exceedingly acute, that relief is experienced from this single measure. Such a patient should eat light, nutritious non-irritating food and avoid all condiments. A strict milk diet is frequently prescribed, but there is no reason why such patients should be denied a moderate amount of appetizing food. Alcohol should be withheld, although some of our German associates believe that an occasional glass of beer is harmless if given to those who are accustomed to it. Posner allows beer and red wine. The bowels should be kept freely open by mild laxatives, such as cascara and phenolphthalein given at night, or small doses of saline in the morning. Hot compresses, or hot-water bags applied to the suprapubic region are often very helpful. In the male, owing to the frequent association of posterior urethral inflammation, hot rectal douches or hot sitz baths are often extremely beneficial.

The medical treatment of acute cystitis is twofold: to alleviate the distressing symptoms and to combat the infection. For the relief of the former we must attempt in the first place to render the urine as bland as possible by the ingestion of large amounts of water, and the administration of alkalies. Bicarbonate of soda, given in doses from 10 to 30 grains three times a day, is given frequently to lessen the urinary acidity; it possesses also slight diuretic and antiseptic proper-

ties and does not upset digestion as some of the other alkalies frequently do. The most commonly used alkalies are potassium citrate, potassium acetate and liquor potassæ. In acute cases either the liquor potassæ or the acetate are more serviceable. The combination of these drugs with sedatives is frequently employed, the most common and efficient being potassium acetate, 15 gr. and tincture of hyoscyamus, 15 drops to a dose three times a day after meals.

℞—Pot. acetate,		
Tinct. hyoscyam.	āā	℥j
Water	q.s.	℥vj

M. Sig.—Two teaspoonfuls in a little water after meals.

℞—Liquor potassæ		℥ij
Ext. hyoscyam.		gr. x
Tinct. opii camph.		℥j
Syr. acaciæ		℥ij
Water	q.s.	℥vj

M. Sig.—One tablespoonful in glass of water after meals.

Sweet spirit of niter, 20- to 40-m. doses, has been used particularly in cases of women, but at present is not very frequently employed.

For the tenesmus and distressing urinary symptoms it is often necessary to give anodynes in association with urinary sedatives. A suppository containing $\frac{1}{2}$ gr. powdered opium, $\frac{1}{4}$ gr. extract of belladonna is often most beneficial to relieve these conditions. The dose is small and it may be repeated. Sodium and potassium bromides given in 10- to 20-gr. doses are often beneficial. A very convenient form and satisfactory preparation of the bromides, is the combination of the three bromides, ammonium, sodium and potassium prepared in the effervescent wafer. This combines the quieting effects of the bromide, and the alkali. In case the symptoms are severe either morphin, gr. $\frac{1}{8}$ to $\frac{1}{4}$ hypodermically, or codein, $\frac{1}{2}$ gr. hypodermically, may be necessary.

To combat the infection the administration of internal antiseptics and the application of local measures are at our command. The internal urinary antiseptics which are most efficacious are urotropin (hexamethylenetetramine) salol, benzoic acid, acid sodium phosphate, helmitol (anhydromethylene-citrate of urotropin), hetralin, borovertin, cystogen, and certain of the balsamics, particularly sandalwood oil, copaiba, and cubebs. The most important of these drugs are urotropin and sandalwood oil. The administration of one or the other of these remedies depends in a great measure upon the character of the infection. In a gonorrheal cystitis the balsamics find their most useful field. In the staphylococcus and streptococcus infections urotropin is preferred, provided the urine is made acid by large doses of benzoic acid or acid sodium phosphate. In colon, typhoid and influenzal infections, particularly the colon, which is the most frequent, urotropin finds its most important province. In alkaline cystitis due to proteus infection and also that due to the urea-splitting organism,

urotropin again is the most serviceable, provided the urine is rendered acid by the administration of large doses of acid sodium phosphate or benzoic acid; acid sodium phosphate is decidedly the superior drug for the purpose of counteracting alkalinity.

Urotropin when given is best administered after meals in 10-gr. doses. It may be given in tablet form or in solution. If the patient does not have an idiosyncrasy to this drug it may be pushed as high as 70 to 90 gr. a day. Some patients tolerate these large doses for weeks, others are only able to stand such doses for a few days. The signal for its deleterious effects are gastric distress and vesical irritability, occasionally associated with hematuria. Under such circumstances it has to be withheld and balsamics given in its stead.

In case of the simultaneous administration of an acid with urotropin the combination tends to convert the urotropin to such an extent in the stomach as to cause gastric irritation, as well as a loss of subsequent conversion in the urine, so under such circumstances it is advisable to allow an interval between the administration of these drugs.

The many combinations with urotropin are given in the same dosage and are often as efficacious.

Hetralin is supposed to liberate formalin in an alkaline urine more freely than urotropin. Cystogen, owing to the combination of urotropin with an alkali, is far inferior to urotropin, according to Hinman and Burnam, because it defeats the very principle of its action, in that it renders the urine either alkaline or much less acid, and these authors have shown conclusively that urotropin even if given in large doses will not liberate formaldehyde in an alkaline urine, and only to a very slight extent in a slightly acid one.

Borovertin, which is particularly praised by Posner, is a combination of boric acid and urotropin, which combination, according to him, makes the action of urotropin more effective.

Uraseptin is a combination of sodium and lithium benzoate, piparazin and milk-sugar. It is a diuretic and antiseptic and supposedly possesses some effect as a uric acid solvent. Urotropin itself is generally superior to any of its combinations.

Methylene blue, formerly given so frequently in urinary infections, has at the present time been more or less relegated to the rear. It possesses the unpleasant feature of discoloring the urine, and of exerting harmful renal effects. Its antiseptic qualities are not as good as those of urotropin.

Salol, owing to its liberation of salicylic and carbolic acids, has a definite antiseptic action, but in order to secure such action a dosage so large is required as to be ill borne by the average stomach. When given in large doses it may produce renal hyperemia with the accompanying smoky urine which is seen in carbolic poisoning. It may also give rise to profuse sweating and morbilliform eruptions.

Benzoic acid and its salts have always been supposed to be effective acidifiers of the urine: Ashhurst[1] showed experimentally that there was

really diminution in the acidity of the urine, that the drug has a variable diuretic action and inhibits alkaline fermentation. It possesses valuable antiseptic qualities and is much more digestible than salol. Dose from 30 to 60 gr. a day.

Acid sodium phosphate, in the writer's experience, is the drug *par excellence* for rendering the urine acid. It has been particularly valuable in alkaline cystitis and paves the way for urotropin to do its work. It may be given in doses of from 40 to 90 gr. a day; even with larger doses there is seldom observed any unpleasant effects.

Balsamics.—As previously stated the balsamics are particularly valuable in gonorrheal cystitis. Oil of sandalwood given in 10-m. capsules, one or two in number after each meal, is the best representative of this class. It has the unpleasant effect of upsetting digestion in many individuals. Various preparations of sandalwood, such as gonosan, arrhovin, santyl, arrahoel, are claimed by their producers to be more efficacious and to obviate the disagreeable gastric symptoms. Such a claim, however, seems unjustifiable.

Other balsamics such as copaiba, cubebs and eucalyptol are seldom employed as they are in no way superior to sandalwood oil. Copaiba, prescribed in from 10 to 20 minims three times a day is very nauseating and occasionally causes diarrhea. Cubebs is best administered as the oleoresin in 5- to 15-minim capsules three times a day. Lafayette mixture:

℞—Ol. copaibæ		℥j
Spir. eth. nitros.		℥j
Spt. lav. comp.		℥j
Liq. potass.		ʒij
Syr. simp.		℥iij
Nuc. acac.	q.s. ad.	℥viij

M. Sig.—Two teaspoonfuls three times a day after meals.

This old and battle-scarred, gunshot production is like its illustrious namesake, gone but not forgotten. The most important constituent, ol. copaiba, would serve a better purpose if given alone. The oil of terebinth given in 2- to 10-minim doses is better tolerated by the stomach and can be given over a much longer period than any of the other balsamics. It affords a kind substitute for sandalwood. It is, however, infrequently used. Balsamics when excreted in the urine cause a peculiar odor. When given in large doses, lumbago, burning sensations in the perineum, and bladder irritability may follow.

Demulcents which were so frequently employed in former times are seldom used in urology at the present time, the most important ones which have enjoyed their share of popularity are buchu, uva ursi, triticum repens, flaxseed tea, and corn silk.

Local Treatment.—Many cases of acute cystitis may be cured by hygienic, dietetic measures, and internal medication. The majority, however, are hastened in their cure by local measures to the bladder

itself, which attempt to eradicate the infection. In the acute bladder infections instillations are preferable. The most efficacious of these are argyrol, 25 to 50 per cent., and protargol, 1 to 2 per cent. Nitrate of silver is too irritating for the acutely inflamed bladder, but is the prince of all instillations in one which is chronically infected. Before the instillation the patient should completely empty the bladder, and in case there is much detritus it is often wise to irrigate the bladder gently with plain water before instilling. It is indeed quite remarkable how frequently we see an almost immediate benefit after one instillation of argyrol in the acutely inflamed bladder. In an uncomplicated cystitis the inflammation will almost invariably subside in a week or ten days under such treatment. If it does not, it makes us immediately suspicious of renal or genital infection.

Irrigations.—Irrigations in acute cystitis are far less valuable than in the chronic form; however, mild irrigations given under low pressure without bladder distention may be quite beneficial. In gonorrheal cystitis, hot irrigations of potassium permanganate 1 to 6000 to 8000 are particularly indicated. In the ordinary infections, boric acid and mild bichloride, 1 to 50,000 are extremely valuable. We so frequently hear of surgeons lavaging in the bladder with 1 to 10,000 bichloride. This should never occur, as it is absolutely injurious to any bladder to shoot it with such a powerful irritant; but in the mild strength given above it is seldom accompanied by any irritation, and possesses very great value. Irrigations of hot saline solutions are often very alleviating.

Chronic Cystitis.—The rules of hygiene and diet recommended in acute cystitis are equally applicable to the chronic form of the disease, and will not be discussed in further detail in this paragraph.

As chronic cystitis is so frequently secondary to some coexisting pathological processes, such as renal infections, foreign bodies and stones in the bladder, prostatic obstruction, tabes, and diverticula, it is of prime importance to remove these predisposing causes. When this is accomplished the cystitis will take care of itself in the majority of instances. In case of simple chronic cystitis, and as an adjunct in the treatment of complicated chronic cystitis, the disease may be curtailed by general and local remedies. As a rule medical therapeutics suffice, but in certain rebellious chronically inflamed bladders one may be forced to resort to surgical measures. To render the urine bland is our first object. This is best accomplished by the ingestion of large amounts of water. The average cystitic does not receive a proper amount of water. Many are instructed to drink small amounts in order not to be bothered with frequent urination. Such an idea on the face of it is absolutely erroneous, as the hyperacidified urine will naturally cause more trouble than pale dilute urine from liberal water drinking. Patients should be instructed to drink at least a glass an hour. The alkali waters are frequently prescribed and may be beneficial. Should the individual be suffering with pain and tenesmus,

anodynes and balsamics must be administered. (See Acute Cystitis.) The most valuable combination under such circumstances is:

℞—Potassium citrate	. . . .	ʒj
Tinct. hyoscyamus	. . . .	ʒj
Water	. . . .	℥vj
M. Two teaspoonfuls after meals.		

In more aggravated cases a suppository containing belladonna and opium often proves extremely helpful. In many cases, however, even in the presence of such symptoms, the urinary antiseptics, particularly urotropin, will often very shortly quiet down such irritability by its prohibitive action to bacterial growth.

Depending upon the character of the infection, either urotropin and its derivatives, or the balsamics, particularly sandalwood, are indicated. In colon and typhoid infections, urotropin stands preëminent. It is also the choice in alkaline cystitis if due to a proteus infection, after the urine has been rendered acid by large doses of acid sodium phosphate, from 40 to 90 gr. a day. So, as a general rule, water and urotropin are the most important internal therapeutic measures at our command.

Local Treatment.—Local treatment in chronic cystitis consists in irrigations, instillations, topical applications, and vesical distentions.

Irrigations form our most important means of combating chronic inflammations of the bladder. Nitrate of silver in strengths from 1 to 5000 to 1 to 2000 are unquestionably the most beneficial. It is important that these solutions be made with distilled water to insure us that we are getting nitrate of silver. Silver chloride is much more irritating and far less antiseptic. Bichloride of mercury from 1 to 30,000 to 1 to 60,000 is a very satisfactory and handy solution, and does not possess the disagreeable feature of causing stains. Various drug houses manufacture small tablets from 1 to 30,000 to 1 to 100,000, which added to a quart of water make the desired strength. This is a very simple and handy way of making the irrigation for routine work, and does away with the clumsy stock solution. Potassium permanganate, 1 to 6000 to 1 to 10,000, still holds its own as a valuable soothing irrigation in chronic infections of the bladder. Boric acid, 2 to 3 per cent. solution, is one of the most frequently employed bladder lavages, and is very cleansing and non-irritating. Other irrigations which are less frequently employed are oxycyanide of mercury, formalin, collargol, argyrol, and protargol. In chronic alkaline cystitis the acid irrigations, such as boric and mild hydrochloric acid, are valuable, but the writer has had better results in such instances with the injection into the bladder of Bulgarian bacilli, which generate an acid medium and kill off the alkaline-producing organisms. A full description of this treatment will be taken up in the pages devoted to incrusted cystitis. Hagner, of Washington, reported before the Southern Surgical Association in 1914 some excellent results in alkaline cystitis by

the use of these lactic acid-producing organisms. Irrigations should be given daily in the beginning of treatment until the patient is under control, then two or three times a week. In the male, providing there is no residual urine, the irrigations are best given by hydraulic pressure from a graduated glass irrigator, the nozzle is directly applied to the meatus, and the flow is controlled by digital pressure. After thoroughly cleansing the anterior urethra the patient is told to imitate the act of urination; this will allow the irrigating fluid to pass directly into the bladder. The average individual accomplishes this much better standing over a urinal, as this simulates the ordinary urinary act. In women and with men with residual urine it is always necessary to irrigate through a catheter after withdrawal of the urine. The irrigation should be repeated several times and a small amount left in the bladder following the performance. In some of the stubborn, rebellious cases the continuous irrigation through a two-way catheter is often extremely effective if the patient's urethra will tolerate it.

Instillations.—Instillations do not play as important a role in chronic cystitis as they do in acute, but are frequently of benefit in association with irrigations. Silver nitrate, argyrol, protargol, collargol, cargentos, carbolic acid, and acid-producing organisms are the most important. Nitrate of silver and argyrol seem to be the most effective. In the male nitrate of silver instillations may be given in from 0.5 to 1 per cent. Many German authors give as high as 2 to 3 per cent., but the average delicate American bladder and urethra fall short of tolerating such heroic treatment. In the female 5 per cent. is usually easily retained. Argyrol is used in strengths varying from 10 to 50 per cent.; protargol 1 to 2 per cent. solutions; collargol is generally used in a 10 per cent. solution; cargentos in strengths from 25 to 50 per cent.; carbolic acid in solutions from 1 to 500 to 1 to 50, depending upon the tolerance of the individual. The quantity of solution generally used is from 15 to 60 minims, but I find that the amount which may be given through a Keyes-Ultzman syringe suffices.

Topical applications are often very helpful in the treatment of chronic bladder infections, particularly those in which there are associated ulcerations or localized inflammatory reactions which so frequently occur around the trigone and bladder neck; also in the treatment of various papillary vegetations in vegetative cystitis. These applications are best accomplished through the endoscope, the operating cystoscope, or the Kelly cystoscope in the female and by the endoscope and operative cystoscope in the male. I do not believe that it is necessary in the female to have the patient in the knee-chest position, since they may be as satisfactorily and efficiently treated in a much more comfortable reclining posture. Such treatments consist in the direct application of strong nitrate of silver, as high as 25 per cent., to the seat of trouble, painting the ulcerated area or even the whole trigone. In many of the stubborn ulcers with papillary elongations such as are seen in vegetative cystitis, the high-frequency cur-

rent applied by means of the cystoscope is often a great adjunct in the treatment. I have seen some very stubborn ulcers healed by such applications.

Surgical Treatment.—The surgery of the conditions associated with and responsible for cystitis, such as prostatic obstruction, stricture, foreign bodies, kidney lesions, etc., will not be considered under this heading, as they are described in their respective chapters; suffice it to say that after surgical correction of such pathological conditions the cystitis will usually get well. The surgical methods for obstinate and intractable cystitis may be classified as follows: (1) catheterization; (2) operative cystoscopy; (3) curettage; (4) perineal cystotomy; (5) vesicovaginal fistula; (6) suprapubic cystotomy; (7) nerve resection. Such operations are rarely indicated, except for the relief of bladder distress, associated with double renal disease, and also with genital lesions, which are difficult or impossible to cure. They also find a field of usefulness in the rebellious painful cystitis and for the treatment of vegetations or ulceraticns which do not respond to simple measures.

In some of the intractable cases of chronic cystitis it is often wise before resorting to more drastic measures to put the patient to bed, placing in a two-way catheter for continuous irrigation. This may be kept up for long periods, depending upon the tolerance of the individual. As the bladder under such conditions is usually contracted, it is important to enlarge its capacity by repeated vesical dilatations. This may be done daily or every other day, if the patient bears it kindly, by clamping off the outflow of the two-way catheter, and forcibly distending the bladder by hydraulic pressure; or it may be done by the method of Kelly by daily catheterizations and distentions. It is often remarkable to see how promptly such bladders will dilate. I have had several patients whose bladders were so contracted that in the beginning they held only an ounce, which in the course or several months easily accommodated from 400 to 500 c.c. The charting method suggested by Kelly, whereby one is able to follow the progress of the dilatation, is an admirable suggestion. It not only keeps the physician in accurate touch with the progress of the dilatation, but adds interest to the individual and allows him or her to tolerate the discomfort more willingly. In the true contracted bladders such dilatations prove without avail.

Cystoscopic Treatment.—One is often able to accomplish a great deal by the use of the operating cystoscope, by removing or cauterizing vegetations, ulcerations, leukoplakial plaques, and particularly by the use of the high-frequency current to such diseased areas.

Vesical curettage, which was proposed by Bazy, may be done suprapubically, perineally or through the urethra. When done with the open operations it is nothing more or less than an added phase to the operation. I shall consider its application only through the urethra. It is more particularly applicable to the female on account

of the shortness of the urethra and the facility of palpating the base of the bladder through the vagina. The procedure is as follows: The patient is anesthetized, bladder lavaged, then filled with some of the solution, preferably a mild boric acid or bichloride, a long curette is introduced into the urethra and a finger in the vagina, then one curettes the base of the bladder and trigone under the guidance of the finger in the vagina. This part of the bladder is more easily accessible and can be more thoroughly curetted. The lateral wall of the bladder and dome are more difficult to curette because of their inaccessibility. In curetting the anterior wall and dome of the bladder it is often advisable to make suprapubic pressure and have the hand as counter-pressure against the curette. Various instruments have been proposed for curettage in the male, but none of them have proven successful. Following curettage it is necessary to thoroughly irrigate the bladder and then place a retained catheter for continuous drainage and for repeated irrigations and instillations. Perforation of the bladder following curettage has been exceedingly rare, as shown by statistics of Imbert,[32] Poisson and Trendelenburg. Imbert's 32 collected cases of non-tubercular rebellious cystitis show 26 per cent. cures, 35 per cent. improvements, and 39 per cent. failures.

Perineal section, particularly advocated by Thompson, consists in making a small perineal urethrotomy at the apex of the prostate and inserting a Pezzer catheter to be retained until the disease becomes quiescent. The catheter may be kept in place from fifteen to thirty days, it is then removed and the wound allowed to close. Fistulæ seldom result. This operation has been attended with a surprisingly high mortality; Imbert[31] reports 5 deaths in 22 operations. Hartmann[26] in 71 operations had 14 deaths. This is due to complicating renal disease. Concerning the results of those who lived, Imbert had 22 with 8 cures, 8 improvements, 1 no improvement. Legueu[38] has had 2 complete cures in rebellious cystitis, which resisted all therapeutics. The disadvantage of the perineal route is that the catheter is at times distressing as it passes through the sphincter and posterior urethra. The chief disadvantage, however, is that one is not allowed to see the pathological condition of the bladder and to make applications to, or resection of, the disease.

In the vesicovaginal procedure the success of the operation depends entirely upon drainage, the opening of the bladder is made in the midline through the anterior vaginal wall. The two mucous membrane surfaces are brought together and united with catgut. The fistula is allowed to remain open for a long time until the cystitis is cleared up. This may take years. It is done particularly for cystitis dolorosa. One uncomfortable feature of this operation is that occasionally the vaginal sphincter contracts and closes the vaginal orifice, so that urine accumulates in the vagina, producing severe vaginitis, and does not allow the bladder to drain freely. This is obviated by cutting the vaginal sphincter posteriorly, and following this

with dilatation. Such a procedure is generally necessary in nulliparæ. Imbert's collected series of 29 cases show 19 complete cures, 4 markedly improved, 5 fair improvements, and 1 no improvement. Persistent fistula will follow vesicovaginal procedure in about 50 per cent. of the cases, and will require secondary plastic operations for closure. For a prolonged continuous drainage in women this method is superior to the suprapubic, it gives better drainage, and also allows topical applications to local conditions as does the suprapubic. A very helpful treatment in such conditions is the continuous tub-bath treatment, advocated by Hunner, the purpose of which is to keep up continued drainage and thorough cleansing of the wound and bladder. The patient is placed in a tub of water at about 100° F., allowed to remain in as long as she can stand it with comfort, usually about one-half hour in the beginning. As the patient becomes more tolerant to this treatment the time may be increased to three or four hours twice a day and the patient be perfectly comfortable. This is kept up for weeks until the bladder is perfectly quiescent.

Hunner and Kelly have reported very satisfactory results with this treatment in conjunction with suprapubic or vesicovaginal fistula, or both. Another method to assist the healing of the bladder in conjunction with a vesicovaginal fistula is continuous irrigation through an indwelling catheter. The patient may be placed in bed on a Taylor pad, which is a double ring pneumatic pad with a drainage hole in the centre, directly over which the patient's buttocks are placed. The drainage tube goes directly through a hole in the mattress and spring of the bed and the patient may be kept entirely dry.

Suprapubic cystostomy possesses the distinct advantage of allowing more thorough inspection of the bladder, permitting the operator to employ such measures as he feels are essential, such as curettage, cauterizing and burning vegetations, ulcerations and leukoplakial plaques, or the removal of sequestrated gangrenous, exfoliated membranes, the excisions of ulcers and cicatrices. The operation is essentially the same as the ordinary cystotomy for stone, except that the bladder is usually small and contracted and fixed well down in the pelvis, making it more difficult. After one has made the necessary surgical attack to the bladder, it is closed around a drainage tube, the prevesical space is drained, and the abdominal wall partially closed. With the bladder open in this manner local applications may be continued in order to hasten healing, or continuous irrigations may be employed either through an inlying catheter through the urethra or by continuous tub.

Resection of the internal pubic nerve has been proposed by Rochet[53] for the treatment of painful cystitis which had resisted all forms of treatment. He reported 6 cases, 3 in the male, 3 in the female. Two of the males were cured, one improved, and all the females were cured. Such an operation puts the bladder at rest and may entirely relieve the pain as Rochet has suggested. It is an operation which may lead to vesical paralysis and one which is very infrequently employed.

TRIGONITIS AND TRIGONAL HYPEREMIA.

In the vast majority of chronic infections of the bladder the trigone bears the brunt, and most of our complicated pathological pictures of vesical infections are found in this location. These have been described in detail under the paragraphs devoted to acute and chronic cystitis, and the reader is referred to these paragraphs for a complete description. Garceau and Kelly[20] have given us excellent descriptions of trigonal disease. The symptoms, cystoscopic appearances, diagnosis in general, and treatment may be found in the same paragraphs, as the disease cannot be clinically differentiated from a general cystitis.

Trigonal hyperemia, a common bladder complication in many pelvic diseases in women and often associated with posterior urethral diseases in men, frequently resisting most carefully directed treatment, forms such an important chapter in bladder disease that it is worthy of detailed description.

Trigonal hyperemia is a circulatory disturbance of the trigone and is evidently due to mechanical changes, so frequently associated with various types of pelvic disease. The symptoms are often very distressing and are indistinguishable from inflammatory diseases of the bladder. They are characterized by increased frequency of urination, especially diurnal, worse when the patient is up and about, often transitory and variable. Pain at the end of urination is a common accompaniment. Pain in some cases even amounts to tenesmus. Referred pains are usual, most frequently located in the suprapubic region, and in the lower back. Such low backaches in women are as frequent as backaches in men from chronic posterior urethral involvement. They are, however, due not only to the trigonal hyperemia but to the associated pelvic abnormalities. The urine in contradistinction to inflammations of the bladder is generally clear and sparkling, so that when one has such a clinical picture with diurnal frequency and pain associated with clear urine the diagnosis of trigonal hyperemia is almost assured. Blood cells are occasionally found in the urine, due to diapedesis; pus cells are extraordinarily rare.

Cystoscopic Diagnosis.—The insertion of the catheter usually produces discomfort, as such bladder necks are often exceedingly sensitive. The bladder capacity is usually restricted, owing to its lack of normal distention from frequent urination. The cystoscope shows the bladder wall to be generally entirely negative. The trigone, characterized by intense redness due entirely to hyperemia, stands out cleanly demarcated from the otherwise normal bladder. One sees vascular dilatations which are usually more common around the region of the ureteral and the internal vesical orifices. The ureteral orifices themselves are entirely normal. With such a trigonal picture there is usually associated a crescentic blush of the lower part of the vesical sphincter. This congestion is also seen almost invariably along the posterior part of the urethra. As has been said, the bladder mucous

membrane is normal, but frequently one sees bladder distortions and intravesical projections from associated pelvic disease. With such a picture of normal bladder, hyperemic trigone, congested posterior urethra, and lower sphincter margin, coupled with a clear urine and distressing bladder symptoms, the diagnosis of trigonal hyperemia is certain.

Treatment.—The correction of pelvic disease will frequently eradicate such symptoms. There are, however, many cases in which, after thorough removal of complicating pelvic processes, the symptoms are unrelieved. For these cases, even though some say more harm may be done than good, I am convinced that a great deal of good may be accomplished by treatment. On innumerable occasions such distressing symptoms have been entirely relieved by treatment which is about to be outlined.

In the out-patient department of the Washington University these cases have been treated in conjunction with the gynecological clinic, and we have been able to relieve by proper treatment many of these inveterate sufferers. The treatment consists of applications to the trigone, internal orifice and urethra, dilatations of the urethra and vesical distention. Such patients are usually treated in the beginning, three times a week. After filling the bladder with an antiseptic solution and using great care in asepsis the urethra one day is dilated with the Kollmann dilater; on the next visit the bladder is distended by means of the catheter and irrigation, following which there is usually given an instillation of nitrate of silver from 1 to 5 per cent. to the trigone and bladder neck. These treatments are occasionally interspersed with endoscopic applications of nitrate of silver to the trigone. As the patient improves the interval of treatment is lengthened. We have been surprised as well as delighted with the great improvement and in many instances complete cure of any number of such individuals, who have received all sorts of treatment other than that directed to the bladder for months and years previously without any apparent benefit.

We have been particularly impressed with the marked improvement in the reflected pains. It is surprising how rapidly the backaches have been relieved. The urinary frequency and discomfort and the bearing-down sensations which are common also have been speedily alleviated. So far as we know there has been no cystitis develop following our manipulations. In the light of these results we believe that such individuals should not be stamped with a life of torment, but given such treatment, even with the possibility of incurring cystitis, which we believe ought to be a rare complication, if treatment is properly conducted.

INCRUSTED CYSTITIS.

An occasional complication of a rebellious alkaline cystitis is incrusted cystitis. This very stubborn form of alkaline cystitis has

PLATE I

FIG. 1

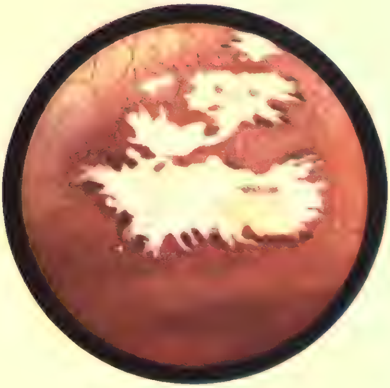
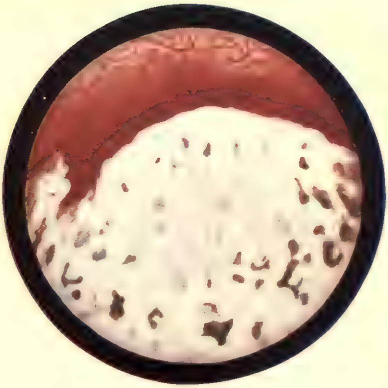


FIG. 2



Incrusted Cystitis. (François.)

occurred once in the writer's practice and formed the basis of a report before the American Association of Genito-urinary Surgeons, 1914.[9]

The pathogenesis of this disease is no more definitely understood than is that of incrustation elsewhere. It seems most probable that the combination of infection, necrosis and urinary supersaturation are the most important factors, but as Lichtenstern and others have said, just why the organism should cause necrosis and incrustation in one case and proliferative changes in another is unknown. The bacteria which have been found in association with it are proteus, staphylococcus, colon, and the tubercle bacilli.

Incrusted cystitis has been observed as a concomitant disease with gonorrhea, stricture of the urethra, chronic cystitis, hypertrophy of the prostate, bladder tumor, renal tuberculosis, pyelonephritis, around vesicovaginal fistulæ and foreign bodies.

Its inception frequently occurs during the puerperium, the so-called puerperal cystitis, which was evidently the cause of the disease in the case described, as her initial symptoms dated one month after the birth of a child. There was probably another etiological factor, as she had been a great lemon eater and vegetarian.

There are two types of incrusted cystitis: The flat or surface type (Plate I, Fig. 1), and the elevated or tumor-like (Plate I, Fig. 2). These may occur alone or be associated. The first is more commonly seen behind stricture, prostatic obstruction, around vesicovaginal fistulæ, and capping bladder tumors. When the two are associated the flat or surface type is more commonly seen around the internal orifice of the bladder. The elevated or tumor-like is the rarer and more interesting of the two, and is due to the constant precipitation of salts on the already incrusted ulcer. In gross these masses resemble small, irregular tumors, studding usually the trigone and bladder base, covered with a soft, downy, whitish-gray, granular material which Marion describes as resembling a sponge. The small masses are soft; the larger ones quite firm. They are very adherent to the bladder wall, and upon their removal a punched-out ulcer with irregular edges is left in the mucosa. The bladder shows a general, intense, acute cystitis, with marked edema. The slightest touch causes bleeding. This edema is not confined to the bladder but extends along the urethra and causes the same intense reaction at the meatus. Pyelonephritis is a common complication; this did not obtain in our case. The incrustation is usually limited by the submucosa, but in the more advanced cases the whole bladder wall may be infiltrated.

The large masses resemble true stones; the smaller ones and the incrusted ulcers show a micropathology similar to that described by other authors who have studied this subject, namely: a superficial necrotic zone containing islands of incrusted material (Fig. 33) and thrombosed vessels, and beneath this a dense zone of infiltration. Here and there islands of mucous membrane remain, and in the case cited there were several villus-like projections which resembled vesi-

cal papillomata (Fig. 34), but were evidently chronic proliferated changes. These villus-like formations are frequently observed in chronic ulcerative cystitis.

Fig. 33.—Incrusted cystitis. Case (S. Y.), Washington University, St. Louis, cured by Bulgarian bacilli.

Fig. 34.—Incrusted cystitis, showing villous projections of the so-called vegetative cystitis.

The most distinguishing pathological characteristic of this disease is its tendency to rapid recurrence. The tumor-like masses can be entirely removed and within forty-eight hours are completely replaced. The salty precipitate which is usually present in incrusted cystitis is generally composed of phosphates. The incrustations occurring in an acid urine differ from this type in that they are more shell-like, and when removed do not show the tendency to tear.

Symptoms.—The symptoms of this disease are usually those of a very aggravated cystitis, starting with marked increased frequency of urination, and hematuria which is terminal at first but finally constant. In the case reported the hematuria persisted for three years without remission. The urine is generally highly alkaline and urination very painful, and a characteristic and almost pathognomonic symptom is the repeated passage of calcareous material in the urine. The diagnosis is not always easy. The cystoscope offers our only intelligent means, and often cystoscopically one may be mislead as to the true nature of the condition. At first I was entirely mistaken in the diagnosis of my case, as I thought I was dealing with multiple papillomata which had become incrusted, particularly in the light of the fact that the patient had undergone a previous suprapubic operation supposedly for tumor.

The tumor-like incrustations present an interesting picture, and are extremely difficult to differentiate from incrusted tumors. The chief points of difference are that they are not composed of long villi, are very firm, with surfaces usually irregular and downy, and that by means of the ureter catheter only the superficial downy material can be moved about. Further, the removal with an operative cystoscope shows the masses not to be composed of villi but of inflammatory tissue and calcareous deposits. These elevated incrustations have been mistaken for true calculi. The diagnosis can usually be made by the fact that they are fixed to the bladder wall, and occur in different parts of the greatly inflamed bladder. A point to be remembered is that the intense cystitis with such marked edema makes it often difficult to determine the fundamental cause of the incrustation, for in our case, among other things, an incrusted tuberculous bladder was considered, but the usual standard tests for tuberculosis were negative. It is often impossible to locate the ureteral orifices, since these deposits so frequently cover them.

An important diagnostic point is the therapeutic test of acidulating the urine, thereby causing rapid evacuation of the tumor masses, demonstrating the remaining ulcers, quieting down the cystitis so that a more thorough inspection is possible and permitting ureter catheterization in order to examine the upper tract.

Treatment.—Naturally, with a disease so obstinate and so rebellious, one would expect to find many methods of treatment proposed. All the standard lavages and instillations have been utilized, namely, bichloride of mercury, lithium salicylate, silver nitrate, weak solutions

of acetic acid and lactic acid, iodin, etc.; coupled with these, internal urinary antiseptics, particularly urotropin and its derivatives. None of these has produced lasting effects or curative results, and most of the afflicted individuals have been finally forced to undergo surgical interventions.

Surgically this problem has been attacked endovesically, suprapubically, and in rare instances vesicovaginally. The surgical principles which have been employed have been curettage, excision, and drainage, the idea being to remove the calcareous material and to drain the bladder in order to prevent its reforming. Curetting the bladder through the urethra has been employed by several men, notably Marion, Unterberg, Francois and others. This method has been used only in the female. By this means these authors claim that the bladder mucous membrane can be thoroughly removed and that cure frequently follows. After the curettage, a retained catheter is usually placed. This method is simple of execution and without particular danger; it possesses the extreme disadvantage, however, of being a blind surgical procedure, and one knows neither the extent nor the thoroughness of one's manipulations. It frequently is attended with rapid recurrence. Francois[18] shows 50 per cent., and in the author's case recurrence was almost immediate.

The suprapubic methods have been thorough curettage in an open bladder, curettage with the application of iodin and other chemicals, either with closure or with temporary fistulæ; and finally excision of the tumor masses and ulcerations with suture of the mucous membrane, as has been done by Lichtenstern, Latzko, Zuckerkandl and Marion. These suprapubic operations have been attended with a high percentage of recurrences except those in which the ulcers were resected and the mucous membrane sutured. This procedure seems to have offered fairly satisfactory results.

The above treatments are usually not satisfactory and are attended with frequent recurrences. The treatment which was so effective in my case consisted in the intravesical injection of Bulgarian bacilli, the idea of such treatment being to have these organisms proliferate and produce an acidity which would be incompatible with the life of the organisms responsible for the disease. The method is very simple: dissolve three or four tablets, which are prepared by various drug houses, in about $\frac{1}{2}$ ounce of water and add a little milk-sugar. After the bladder has been evacuated by means of a catheter, inject this emulsion which is to be retained as long as possible. As the organisms are perfectly harmless to the bladder, they may be injected frequently. In case the patient is suffering with marked frequency of urination they may be employed twice a day in the beginning, then daily. Further injections will depend upon the progress of the disease. In the author's case, improvement was almost immediate, and in a few days the patient had evacuated large amounts of calcareous material, the hematuria had ceased, and within ten days the patient's

urine was perfectly clear. When the urine becomes acid and this acidity is found to be due to lactic acid bacilli, usually one or two bladder irrigations will kill off these organisms. This type of therapy seems very effective in many forms of alkaline cystitis.

TUBERCULOSIS OF THE BLADDER.

Tuberculosis of the bladder is almost uniformly secondary to renal or genital tuberculosis, although cases of primary tuberculosis of the bladder have been described by Casper,[8] Fenwick and Kelly.[17] Casper found 3 cases of true primary tuberculosis of the bladder in 34 cases of bladder tuberculosis. These primary infections have frequently followed gonorrhea, which is believed to prepare the soil for tubercle bacilli. The bacilli may pass through normal kidneys, which has recently been shown by Brown, of Saranac, to occur with comparative frequency. I have had but one case in my experience of undoubted vesical tuberculosis in which a coexisting lesion of the kidneys or genitals could not be determined. Tuberculosis of the bladder may remain pure for a certain period, but almost invariably secondary invasion takes place, particularly infection with a colon bacillus, and a tuberculous cystitis develops.

Etiology.—The predisposing causes of tuberculosis of the bladder are traumatism and obstruction, although innumerable cases occur in which no such predisposing factors can be determined. Tuberculosis in other parts of the body affords a most important factor, particularly since 10 per cent. of all cases of pulmonary tuberculosis show tubercle bacilli in the urine without demonstrable renal changes, and since practically all cases of renal tuberculosis, and 5 per cent. or more of genital tuberculosis show tubercle bacilli in the urine, it is easy to see how tuberculosis of the bladder may be a common companion.

Whether or not gonorrhea affords a predisposing factor of any importance is difficult to state, as gonorrhea itself is so frequent. Of Walker's 135 cases, 71 gave a history of a previous gonorrhea.

Bladder tuberculosis occurs usually in the young adult, between the ages of twenty and twenty-five, although I have seen one case in which no symptoms of any urinary distress had developed until the age of seventy, when the patient was found to have a marked tuberculous cystitis associated with double renal tuberculosis. Males are affected twice as frequently as females. This is probably explained by the fact that bladder tuberculosis is frequently secondary to genital infections in the male and practically never in the female.

Tuberculosis of the bladder occurs with such frequency that any vesical irritability should excite one's suspicion, particularly if it is not promptly relieved by the ordinary methods utilized in the treatment of cystitis. The active cause of bladder tuberculosis is always the tubercle bacillus, which most frequently descends from the kidney, but may ascend from the genital tract, the original genital focus

being in the epididymis, prostate, or vesicles. Such patients often present themselves at so late a period in the disease that it is frequently impossible to determine the starting-point, as there is often a complex picture of genital, renal, and vesical tuberculosis. Tubercle bacilli may reach the bladder otherwise than through the ureter and genital tract by way of the blood stream and lymph channels, and possibly by direct transmission through the urethra during coitus.

Pathology.—Tuberculous infection of the bladder may occur either as a simple vesical tuberculosis or as a tuberculous cystitis. In the beginning, tuberculosis of the bladder confines itself about one or the other of the bladder orifices. If descending from the kidney the process is usually more pronounced around the corresponding ureteral orifice. If secondary to the genital tract its location is more frequently around the trigone and internal orifice of the bladder. The pathology of vesical tuberculosis has been extensively studied by Hallé and Motz,[24] and they divide the process into four stages: tubercle formation and vesical ulceration, profound ulceration with vegetation, total destruction of the bladder wall, and perivesical lesions. Although most pathologists describe the early stage of vesical tuberculosis to be that of tubercle formation, we very frequently see, cystoscopically, hyperemia and edema around one or the other orifices associated with renal tuberculosis before tubercle formation has occurred.

When the tubercles occur they appear as gray or transparent nodules, occasionally disseminated, but frequently confluent around one of the bladder orifices. The mucous membrane over these tubercles at this stage is usually smooth, since the tubercle formations occur in the subepithelial tissues. Occasionally these tubercles form a complete ring, a corona, around the ureteral orifice. Later on these small areas become yellow, due to caseation. At this stage the epithelium is usually destroyed and superficial ulceration is apt to occur, forming a tuberculous ulcer, surrounding which is an intense zone of hyperemia (Fig. 35). A tuberculous ulcer is usually rounded, and even if confluent the line of junction is rapidly eliminated. The base is usually of a grayish-yellow color. The edges are shaggy and frequently undermined. The bladder wall in the region of such a process shows infiltration with round cells and embryonic connective-tissue cells and marked vascularity. The bladder mucous membrane often proliferates between the areas of ulceration, forming vegetations, rich with capillaries, giving it a shaggy aspect. This is particularly seen following secondary invasion.

In the second stage of more profound ulceration Hallé and Motz find that between these ulcerations there are often elevations which are due either to large embryonic vascular vegetations or to denuded muscle bundles. In some of the more severe cases of ulceration they have found that the whole internal surface of the bladder is formed by the denuded musculature. With this extensive destruction of the bladder mucous membrane and submucosa the musculature becomes

infiltrated. A special type of profound bladder tuberculosis has been described by Hallé and Motz as a massive caseous infiltration. In such cases the internal surface of the bladder is thick and yellow, and the whole bladder wall is converted into a caseating mass without vascularity and without a trace of normal structure. They have found this six times in their observations.

With a more gradual process the bladder wall becomes markedly thickened and infiltrated by connective tissue. Such bladders are non-dilatable, rigid, markedly contracted, and difficult or impossible to cure.

Pericystitis is quite a common complication of chronic infiltrated vesical tuberculosis. It usually consists in a gradual fibrolipomatous sclerosis which produces adhesions between the bladder and neighboring structures. Tuberculous perivesical abscess is rare and rupture of a tuberculous bladder is exceedingly so.

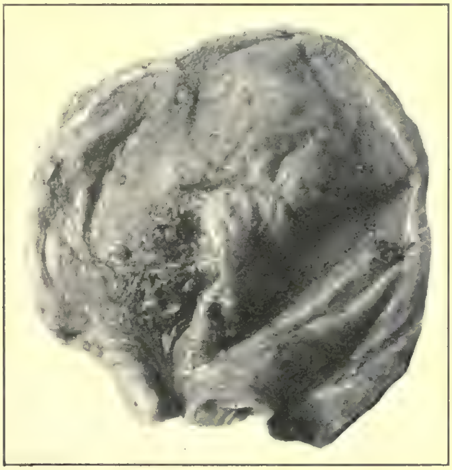


FIG. 35.—Tuberculosis of the bladder with ulcerations. (From Brady Urological Institute, Johns Hopkins Hospital.)

The histological changes of bladder tuberculosis are similar to such changes in other organs, consisting in tubercle formation composed of lymphoid, epithelioid, and giant cells, with areas of caseation, with a surrounding new-formed connective tissue. A detailed histological description is not necessary.

Symptoms.—The symptoms of tuberculosis of the bladder are often indistinguishable from those of ordinary cystitis. There are, however, certain characteristics which may help us in our differentiation, but the cystoscope and the detection of the tubercle bacilli in the urine give us our only means of absolute determination. The disease is generally slow in its onset and equally slow in its progress, prone to periods of quiescence, equally prone to periods of exacerbation. Hema-

turia is often the symptom which attracts the individual's attention to the disease, and it is generally quite typical. Ordinarily it occurs as a few drops of blood at the end of urination as terminal hematuria, but it may be mixed, producing a smoky urine. It forms a very important symptom of the disease, and is generally present throughout its course. This hematuria differs from the hematuria of stone or foreign bodies in that it is not influenced by rest or motion; it differs also from the hematuria of tumor in that it is seldom profuse, intermittent, or painless.

Frequency of urination is ordinarily the initial symptom, and by all means the most annoying one. It occurs both day and night, being uninfluenced by rest or motion to any decided extent. As the disease progresses, frequency becomes a most distressing symptom, and in the period of marked ulceration and contracture it may promote an almost constant desire to urinate.

With this increased frequency of urination pain soon appears, which at first is terminal and often reflected to the meatus and genitals. In the more pronounced cases there may be terrific tenesmus and it is with this tenesmus and pain that hematuria is accentuated. As the disease progresses this terminal pain becomes more and more distressing.

If secondary infection has occurred, pain becomes more pronounced, causing a constant urgent desire to urinate. Such bladders are extremely sensitive and intolerant to any instrumentation. Nitrate of silver, instead of being soothing and helpful, as in simple cystitis, is absolutely intolerable to the tuberculous bladder. These two features, the repugnance of the bladder to instrumentation and to silver instillations, often give the first clue to the diagnosis.

Incontinence and retention are occasional symptoms. The passage of calcareous material is frequently observed.

The urine of tuberculosis presents the following features. A most constant feature is its reaction, which is almost invariably acid. Even in the presence of alkaline-producing organisms, particularly the cocci, it is rare to see a tuberculous urine alkaline. The specific gravity is low. It is commonly bloody, usually smoky, occasionally a deep red. Often it presents a pale milky appearance, which to my mind is very characteristic. Albumin is almost always present. Microscopically there is blood, pus, and epithelial cells. Bacteria may or may not be observed with the ordinary stains; colon bacilli and the staphylococci are the ones most often found. If the ordinary stain shows pus and blood and no bacteria, tuberculosis should be suspected and a thorough search for tubercle bacilli should be made. They can be found in 80 per cent. or more of all tuberculous urines.

Diagnosis.—Any cystitis which does not yield to the ordinarily accepted treatment should excite one's suspicion as to its being tuberculous, particularly if the patient gives a history of frequency of urination and the passage of blood in the urine, which is uninfluenced

PLATE II

FIG. 1

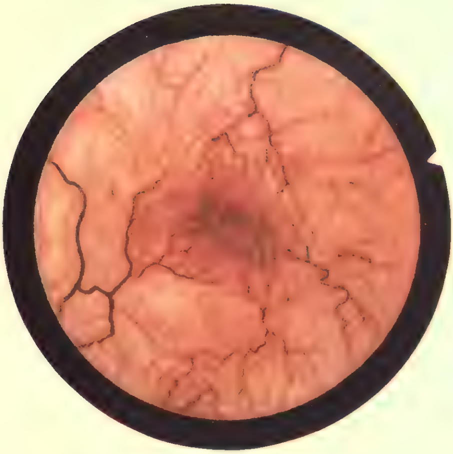
Tuberculosis of Bladder. Tubercle Formations.
(Heitz-Boyer.)

FIG. 2

Tuberculosis of Bladder. Corona of Tubercles around Ureteral Orifice. (Heitz-Boyer.)

PLATE III

FIG. 1



Tuberculosis of Bladder, showing Vascular Arborizations. (Heitz-Boyer.)

FIG. 2

Tuberculosis of Bladder with Ulceration. (Heitz-Boyer.)

by rest or motion, and which in the beginning was terminal. The cystoscopic findings, the detection of tubercle bacilli in the urine, and positive guinea-pig inoculations make the diagnosis absolute. Therefore the essential factor in the diagnosis of tuberculosis of the bladder is investigation.

Cystoscopic Diagnosis.—The bladder is usually contracted, frequently to the extent of one ounce or even less. Cystoscopic examination may be difficult, owing to vesical irritability. One of the early changes of vesical tuberculosis, if secondary to renal tuberculosis, is the hyperemia and edema noticed around the ureteral orifice on the side of the disease. One may also see little grayish-yellow tubercles around the orifice (Plate II, Fig. 1). These are usually multiple and may encircle the orifice (Plate II, Fig. 2). Later on, as they break down, one may see small ulcers with yellow, irregular bases and bright red margins (Plate III, Fig. 1). If the process is more extensive, this same picture may be observed in different parts of the trigone and bladder wall. Petechial whorls and ecchymotic spots are frequently seen at the dome of the bladder (Plate III, Fig. 2), being in all probability due to transmission of infection from the trigone to the dome by the contact of these surfaces when the bladder is empty. If vesical tuberculosis is secondary to genital tuberculosis, the most intense picture is seen around the internal orifice of the bladder and may extend out in any direction from this and not focalize around either of the ureteral orifices. Bullous edema is a common observation in association with tuberculosis of the bladder (Plate IV, Fig. 1).

As the process progresses, if it is secondary to kidney, the ureteral orifice on the affected side becomes irregular and ragged and numerous shreds of fibrin may be seen hanging from the ulcerated area. Old healing processes lead to contracture and distortion of the orifice and frequently cause the formation of the well-known golf hole ureteral opening (Plate IV, Fig. 2). On the other hand, there may be sclerosis, with stricture formation and in rare instances, complete obliteration of the orifice, as in the cases reported by the author at the American Urological Association, 1915. If secondary infection supervenes a kaleidoscopic picture may occur, due to the appearance of ulcers, generalized cystitis, vegetations and papillary prolongations. A case which I saw two years ago had a bladder completely filled with long, shaggy green villi resembling sea weed. With such cystoscopic pictures and the finding of tubercle bacilli in the urine the diagnosis of tuberculosis of the bladder is certain. It then remains for the surgeon to determine the source of the tuberculous infection.

Prognosis.—The prognosis of tuberculosis of the bladder is at the present day good, provided it is detected early enough, since it is so frequently secondary to a unilateral kidney infection, and if this is removed the bladder will usually heal. If secondary to genital disease it will also heal if the process has not gone on to massive genital tuberculosis. If we can teach the profession to realize the importance of

nodular epididymes, many a patient will be spared tuberculosis of the bladder.

Tuberculosis of the bladder secondary to bilateral renal tuberculosis or massive genital tuberculosis offers a very unfavorable prognosis for cure, but may receive relief if properly cared for. Old sclerotic tuberculous bladders with thickened, ragged walls are particularly stubborn and resistant even if an offending kidney is taken away.

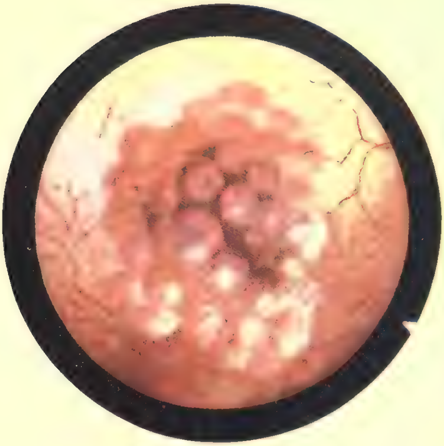
Treatment.—If tuberculosis of the bladder is secondary to a unilateral kidney disease it will usually heal after the removal of the kidney. If secondary to genital processes which are correctable it will also usually heal. If, however, it is due to bilateral renal disease, to massive genital disease, to an old bladder process which has not healed after the removal of the primary focus, or to a primary infection of the bladder the treatment resolves itself into general and local therapy.

The general treatment consists in proper hygiene, proper food, tonics, and serotherapy. The local measures are instillations, enfumages, topical applications, and after healing is sure, vesical distention if necessary. The hygienic and dietetic regime, which in a nutshell consists in plenty of fresh air, good food, proper attention to the bowels and skin, differs in no way from that in the treatment of tuberculosis elsewhere, and needs no special detailed account in this paragraph. It is often wise to give such individuals tonics, the most frequently used being those which contain iron, the most satisfactory of which seem to be the ferri redacti, the citrate, and Blaud's pill. Other frequently employed tonics are cod-liver oil, guaiacol, and creosote. Tuberculin is usually considered to have very little if any beneficial effect on a tuberculous bladder. The reports of Pardoe[49] and Pedersen,[50] however, seem to encourage the belief that occasionally it may be of value. Properly administered it surely can do no harm. From my experience in the last few years I am inclined to think that it may be of great benefit. In one recent case it quieted down the vesical symptoms materially and the patient promptly gained in weight after she had resisted all other therapy for several months. Urinary antiseptics, particularly urotropin, are irritating and harmful.

Local Treatment.—Bladder irrigations should never be given in bladder tuberculosis, as no mechanical distention or irritation should occur. I have seen several cases in which a somewhat quiescent process was absolutely exploded by one bladder irrigation. The treatment *par excellence* for tuberculosis of the bladder is instillation. Carbolic acid, first advocated by Rovsing and later praised by Keyes, is unquestionably, as a general rule, the most quieting and beneficial drug. It is given in strengths of 1 to 200 to 1 to 50. Carbolic acid seems to produce an almost immediate sedative effect on the bladder. Bichloride has long been used and greatly lauded as a panacea to the tuberculous bladder, and is given in strengths 1 to 20,000 to 1 to 2000.

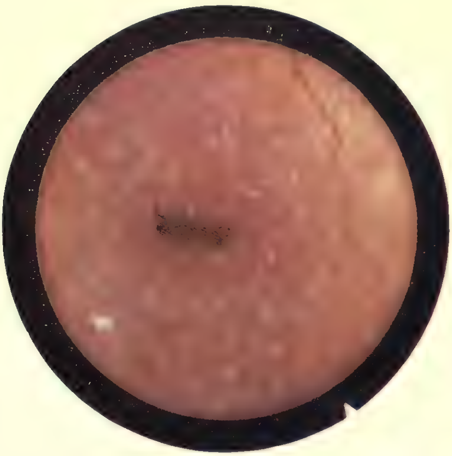
PLATE IV

FIG. 1



Tuberculosis of Bladder. Bullous Edema. (Heitz-Boyer.)

FIG. 2



Tuberculosis of Bladder. Golf-hole Ureteral Orifice. (Heitz-Boyer.)

Iodoform oil follows next as a helpful remedy, being used in a 10 per cent. emulsion; gomenol has many advocates, and is often very beneficial. Nitrate of silver should never be used. One or the other of the above instillations may be given daily, depending upon the tolerance of the individual. Normand and Farnarier[47] have reported some very excellent results in resistant tuberculous bladders by employing iodine enfumage, which consists in passing nascent iodine into the bladder. If properly prepared it is soothing and extremely beneficial. In very stubborn tuberculous ulcers Heitz-Boyer[29] accomplished satisfactory results by applications to the ulcers of the high-frequency current. In a case of the writer's which resisted all other treatments, two applications of the high-frequency current sufficed to effect a complete healing of the ulcer and cure of the patient. The application of the high-frequency current to the tuberculous ulcer is extremely painful and may require a few whiffs of nitrous oxide anesthesia for its administration. Luys[41] reports very beneficial results from the intravesical injection of sterile air, which he employed in 6 cases; the mode of action is not understood.

Operative treatment of tuberculosis of the bladder is at the present day rarely needed. In case hygienic and local measures fail, and the focus of infection cannot be removed, suprapubic cystotomy may occasionally have to be performed. This should be a last resort, as a tuberculous fistula is almost inevitable. Some surgeons have reported cures by curetting, cauterizing, and burning ulcerations through the suprapubic wound; such results are exceptional, and unless one is absolutely forced to it the operation should not be advised.

SYPHILIS OF THE BLADDER.

Syphilis of the bladder, so far as is generally recognized, is quite an uncommon disease. The descriptions given are chiefly those of tertiary, gummatous processes, although a few indefinite cases of secondary syphilis of the bladder have been described. The common bladder picture with that of syphilitic spinal cord disease is not included in this chapter, as it will find its place in an appropriate chapter in this system devoted to the bladder changes in nervous diseases. Men with such vast experience as Nitze and Casper assert that they have never recognized syphilis of the bladder in the living being. Margoulies[42] observed three indefinite cases; Virchow observed a bladder ulceration with an indurated base in a woman infected with syphilis. Griwzow published two cases of syphilitic cystitis; both were very stubborn infections, and finally yielded to syphilitic treatment. Matzenhauer[43] describes small elevated papillomatous projections in the neighborhood of the ureteral orifice, which proved to be syphilitic. MacGowen described the cystoscopic appearance of a case of syphilis of the bladder which showed multiple bladder ulcerations encircling the right ureteral orifice. Le Fur[36] also describes syphilitic ulceration

of the bladder. Englemann[13] observed three cases of gumma of the bladder. Graf and Frank have also contributed to this subject.

Symptoms.—The symptoms of syphilis of the bladder are usually hematuria and vesical tenesmus. Most of the reported cases have had hematuria as the predominant symptom. It may occur with or without pain, and is often quite profuse. Pain and vesical tenesmus are sometimes distressing. There is nothing characteristic about the pain. From a review of the reported cases of syphilis of the bladder it seems that the most common lesions are tertiary. They may occur either as single or multiple ulcers, surrounded by a deep red zone; or as tumor-like masses, either single or multiple, large or small, usually intensely red and beefy and prone to ulceration, bleeding and incrustation. They are very frequently indistinguishable from carcinoma by the cystoscopic appearance.

Treatment.—Treatment of syphilis of the bladder consists in treating the syphilis. Salvarsan, mercury, and the iodides are indicated as in general syphilis. There is no indication for surgery.

SOLITARY ULCERS OF THE BLADDER.

Solitary ulcers of the bladder occur in two forms, either the simple chronic ulcer or the acute perforating ulcer. The etiology of these simple ulcers is far from being understood. Preëxisting infection, toxic influences, and trophic disturbances have been attributed their share as causative factors, but no less an authority than Le Fur[37] is unable to ascribe an absolute etiology. This author produced acute perforating ulcers of the bladder by introducing organisms and toxic products into the vessels of the bladder and also by inducing trophic influences by injury to the spinal cord. The simple solitary ulcer of the bladder is located on the base, back of the trigone. It is clean-cut, round, with slightly elevated edges, with a surrounding zone of hyperemia. The bladder wall is clear. The acute perforating ulcer of the bladder is located most frequently at the dome; it is clean cut punched out, well defined, at times extending through the bladder wall, ending the patient's life with an acute general peritonitis unless proper surgical treatment is given.

Symptoms.—The predominant symptom of simple ulcer of the bladder is hemorrhage. Usually there is an associated frequency and pain on urination. The ulcer, however, may exist with a perfectly clear urine, causing as its only symptom vesical irritability.

The symptoms of acute perforating ulcer are those of simple ulcer with the added evidence of perforation, infection, and general peritonitis.

Treatment.—The simple solitary ulcer of the bladder usually does not yield to instillation treatment. It requires either topical applications directly applied to the ulcer, such as cauterization through a cystoscope, or, as Buerger[7] has suggested, high-frequency application;

or it may demand surgical relief by suprapubic removal. Acute perforating ulcers demand immediate suprapubic section, such as is indicated in rupture of the bladder. If the peritoneum is not involved the ulcer must be resected, the wall sutured, and the perivesical space drained. If there is a coincident peritonitis it has to be cared for by drainage.

BLADDER INFECTION DUE TO ANIMAL AND VEGETABLE PARASITES.

Parasitic infections of the bladder occur very infrequently in this country, and occur only sporadically. They are, however, endemic in certain localities, particularly Africa in the region of the Nile.

Salisbury was the first to describe trichomonas vaginalis in the bladder. Marchand and Dock have observed similar cases. The case of Dock[11] was associated with hematuria.

Other less common parasites which have been found are: Anguillula aceti, reported by Stiles, Eustrongylus gigas, reported by Stuertz, and Falaria.[59]

Chute[10] reported a case of bladder infection due to penicillium glaucum. Such infections of the bladder due to vegetable parasites are rare, and Chute was able to find only one somewhat similar case in the literature until that time, it being the case of von Frisch.[63] Both of these cases had symptoms of severe cystitis. The characteristic urinary finding was that the urine contained white floating masses which were oily and greasy. Chute observed these floating masses cystoscopically at the dome of the bladder. In his case they were made up of penicillium glaucum. Von Frisch's case showed mycelia. Other moulds of this class which may cause bladder infection are oïdium and aspergillus, the latter being comparatively rare. Yeast fungi are frequently seen in urines containing sugar. These do not form mycelia but multiply by sprouting or budding. Sarcinæ urinæ and actinomycosis are occasionally observed. Chute's case was cured by suprapubic drainage, but such conditions can usually be benefited by changing the chemical character of the urine.

PERICYSTITIS.

The bladder is surrounded by loose cellular connective tissue which forms a socket to allow for variations in its distention. The tissues of this cavity are frequently involved by inflammatory changes. The anterior part of this space is divided into three compartments: the retromuscular, immediately above the pubis; the perivesical, commonly known as the space of Retzius, between the anterior abdominal wall and anterior surface of the umbilicovesical ligament; the preperitoneal between this ligament and the peritoneum. This anterior area is particularly liable to infection. Inflammations of the prevesical space

were first called attention to by Trecourt in 1769, who reported a case of abscess in the prevesical space, which he opened and drained. Bernutz, in 1850, gave a clear discussion of inflammations of the prevesical space. Retzius, after whom the space is commonly named, published his first anatomical treatise on this subject in 1856. The important discovery of lymph channels and glands in the perivesical space by Gerota,[21] Bazy, Cuneo, and Marcelli has added greatly to the explanation of many of the perivesical infections. The lymph glands in this region receive lymph from the bladder, and are in communication with the penis and female genitals.

Pericystitis may occur from vesical or extravesical causes, and may be either acute or chronic.

Vesical Causes.—The commonest cause of pericystitis is either acute or chronic cystitis, whether simple or associated with calculus, foreign bodies, diverticulæ, ulcers, tumors, tuberculosis, or obstructions from prostate, stricture, or spinal cord disease. Another vesical cause is rupture of the bladder occurring either from simple trauma or perforation resulting from either bullet wounds or aspirations.

Extravesical causes are those originating in the intestinal tract, most commonly the appendix, sigmoid, and rectum; from diseases of the pelvic structures, uterus, tubes, ovaries, prostate, and urethra; from diseases of the bony structures, particularly the pubis and the spine, the latter through the medium of a psoas abscess; from trauma, such as contusions, bullet wounds, aspirations, and fracture of the bony pelvis; from extension of inflammations, from the retroperitoneal space secondary to perinephritic abscesses, suppurative retroperitoneal glands and echinococcus cysts, and from metastatic causes. The extension of infection to the perivesical space may occur by direct continuity and contiguity by way of the lymphatics and through the blood stream.

With all forms of chronic cystitis there is always a certain degree of perivesical infiltration which is usually of a chronic fibrolipomatous type. However, acute suppurative infections of this space may occur during the course of a chronic cystitis. Whether or not an acute cystitis may be responsible for pericystitis is debatable. Many authors claim that such an association is frequent, but in the light of the splendid work of Hallé and Motz on bladder infections, who have shown that acute cystitis never invades the musculature and that infection could not reach the perivesical space either by direct extention or through the lymph, pericystitis occurring during an acute bladder inflammation would of necessity have to be transported by the blood stream in a very circuitous manner.

Tuberculosis of the bladder is frequently accompanied by pericystitis, which is often very extensive, usually of the sclerotic type, seldom suppurative. It may be either simple inflammatory or tuberculous, the latter being the more infrequent.

Bladder neoplasms are frequently associated with perivesical inflam-

matory changes, which are often so pronounced as to simulate malignant extension. Occasionally acute suppurative pericystitis is a complication of carcinoma of the bladder. Quite recently the writer has observed two cases of carcinoma of the bladder associated with gangrenous cystitis, both of which ruptured into the perivesical space in the region of the tumor and produced large abscesses and in one case a pelvic peritonitis. A common factor in the production of acute suppurative infections in this region is urinary extravasation following bladder rupture. Moschowitz reports a case of extensive perivesical infiltration following suprapubic aspiration.

Extravesical Causes.—It is not exceptional to have suppurative pericystitis complicating appendicitis and sigmoid diverticulitis. There also may be localized infiltrative perivesical inflammations complicating acute appendicitis or sigmoid diverticulitis when these organs approximate the bladder; it may also occur in tuberculosis or cancer of these structures; it is occasionally observed in typhoid fever. Enterovesical fistulæ may occur from either the acute suppurative, the chronic infiltrative, or the malignant processes involving the bladder and intestines.

Diseases of the pelvic structure, both genital and urinary may be responsible for pericystic infections. In the female pericystitis is frequently associated with tubo-ovarian abscesses and inflammations, rupture of the uterus and parametritis. Injuries and fistula of the ureter occasionally lead to infections in this region. In the male, rupture of the urethra posterior to the triangle ligament, rupture of prostatic abscesses and infections of the external genitals have frequently been associated with the infections of the pericystic space. A case which I observed several years ago was confused with double suppurative inguinal adenitis, in which there were large projecting abscesses over Poupart's ligament. On opening these a large amount of pus was evacuated which had surrounded the bladder, and owed its origin to a rupture of a prostatic abscess, the opening of which could be felt in the prostate near the bladder.

Diseases of the bony structure which are occasionally responsible for pericystic infections are osteomyelitis and tuberculosis of the pubis, and Pott's disease, as in the case of Cathelin. Traumata from fracture and from symphysiotomy, as in the case of Williams, are also causative factors.

Symptoms.—Chronic sclerosing pericystitis, which is so frequently associated with chronic cystitis, is productive of no characteristic symptoms, except possibly an aggravation of those which are characteristic of the chronic cystitis. In the acute suppurative infections the symptoms depend upon the cause of the infection. They all, however, have fever, signs of infection and sometimes signs of marked sepsis. The evolution of symptoms is usually rapid, characterized by acute lower abdominal pain, which may be confined to the suprapubic region or bladder. There is usually associated with this marked

intestinal trouble, pain, diarrhea or constipation, frequently confused with appendicitis. Bladder symptoms may be present, such as frequency and dysuria. Later on a tumor develops in the suprapubic region which simulates a full bladder, being exquisitely tender to pressure and painful on motion. When this develops the patient is usually septic and runs a high fever.

A characteristic diagnostic point is that the mass does not subside after the passage of a catheter with withdrawal of the urine.

Treatment.—The treatment of chronic infiltrative pericystitis consists in the removal of its cause, whereas the acute suppurative infections demand immediate surgical drainage through the suprapubic region, although in certain cases in the female, counter-puncture through the vagina is indicated.

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CHAPTER V.

STONE IN THE BLADDER.

By HUGH CABOT, M.D.

Etiology of Stone.—In order to save repetition we will here discuss the whole subject of stone formation in the urinary tract, it being understood that the principle is the same no matter what portion of the tract is involved, and that the formation of stone in the kidney results from causes similar to those which produce stone in the bladder.

It is, on the whole, remarkable that in spite of the enormous amount of work which has been expended upon this portion of the subject we are still far from any sound conclusion. Forty years ago Rainey and Ord brought forward the theory of molecular coalescence in the presence of colloid material, and it appeared that an important contribution had thereby been made. Some years later Epstein, in an elaborate monograph, discussed the nature of the colloid substances in the urine which could lead to stone formation along with the theory previously advanced by Rainey. In essence, the theory of Rainey was that in the presence of colloid material crystalline substances tend to coalesce and take spheroid form. The contribution of Epstein was largely an elaborate monograph concerned with the origin of this colloid material and a theoretical consideration of its influence upon the formation of calculus. The weakness of this doctrine has been well pointed out by Shattuck, who said: "It has commonly been supposed that some adventitious substance is necessary to serve as a starting-point, such as shed epithelium, mucus, blood clot, bacterial colonies, or foreign bodies strictly so called, that is, bodies introduced from without. It is one of the established facts in regard to crystallization that the genesis of crystals as distinguished from their growth takes place only in supersaturated or labile solutions. In the production of such no foreign material is necessary. It will be evident from this that in the formation of uric acid sediments as well as of calculi the secretion of a urine supersaturated in uric acid is necessary before crystallization can occur. The presence of shed epithelium, etc., is not necessary to start it in the supersaturated fluid, and it would be quite unable to do so in the urine which was simply saturated."

The presence of some colloid material in the urine such as shed epithelium may be taken to be the rule rather than the exception, and while therefore it may be a factor in the formation of stone, its pres-

ence is so constant as to render it relatively unimportant. It cannot be regarded as the primary or determining factor. A number of other considerations have been adduced as important, such as heredity, climate, and varieties of diet. All of these, however, seem relatively unimportant. Heredity is perhaps a factor, but one difficult of estimation. Climate can hardly be regarded as important, for even though stone occurs with great frequency in certain districts of the world having a peculiar climate, very similar districts in other portions of the world show a very low incidence of stone formation. Diet, also, after careful consideration must be excluded as an essential factor.

It is important to recognize that a sharp distinction should be drawn between the formation of the nucleus of a stone and the growth of the stone once such a nucleus is formed. It is a well-recognized fact that a small fragment of stone lying in a normal urine which is changed from day to day will continue to grow rapidly even though the urine is not supersaturated or even saturated. It would thus appear that given a nucleus and given a nidus where this nucleus may remain more or less stationary for a relatively short period of time a stone will follow in due order. It is a matter of common knowledge that crystals of sufficient size to form the nucleus of a stone are extremely common in the urine, and from this it would seem to me to follow that if there is some point in the urinary tract where these crystals are caught and retained, even for a short period, stone formation may then occur. If this assumption be sound it follows that the mechanical factor in stone formation becomes an important consideration. Viewed from this angle the element of heredity becomes increasingly understandable. It is easy to appreciate that heredity may affect the conformation of a kidney pelvis or the conformation of the bladder floor. In this way also the influence of environment which has hitherto been laid rather to questions of climate and to errors of diet might become coherent insofar as that environment might give rise to various forms of visceral ptosis, all of which would tend to cause retention and thereby stone formation.

At this point it becomes important to discuss two terms which have appeared largely in the literature of this subject, namely, primary and secondary stone. Many authors have used these terms in different ways. They are commonly used in literature as follows:

The primary stone is one which forms in the presence of uninfected urine, while the secondary stone is that which forms in various conditions of urinary infection, and is, as I believe, erroneously thought to depend upon that infection. That infection is an important factor in stone formation has, I think, yet to be shown. Urinary infections are extremely common and exist for years in patients who show no tendency to stone formation. The importance of infection seems to me to lie not in affecting primary stone formation but in giving rise to renal or vesical retention, and thereby to conditions favorable to the formation of stone. It is not intended to deny that infection in

the urinary tract is an important factor in influencing the kind of stone which forms. Thus, infection with certain organisms, noticeably the pus cocci, results commonly in an alkaline urine. The kind of stone which will form in alkaline urine is essentially different from that which will form in an acid urine. Uric acid and urate calculi, the oxalate calculi and their combination form only in acid urine, while the phosphatic stone forms in the alkaline urine. This, however, does not affect the fundamental question of stone formation but only the kind of stone which occurs. These changes in the urine from acidity to alkalinity when dependent upon infection give rise to different layers of salts in different portions of the stone, and thus occurs the commonly laminated character of many stones. This, however, is getting away from fundamentals, and we are prepared to deny that infection affects the primary cause of stone formation, though willing to admit that it affects important results. The following is submitted as at least a coherent theory of stone formation.

Supersaturated urine is secreted by the kidney under certain conditions which are at present unknown. In this supersaturated urine crystallization occurs. These crystals under certain conditions of retention, whether renal or vesical, are held in the urinary tract for a time sufficiently long to enable them to grow to a size which constitutes a true concretion or calculus. Infection is a factor only insofar as it gives rise to conditions favoring retention, and in that it affects the chemical composition of the stone.

In regard to the origin of vesical calculi some interesting questions arise. Do they necessarily depend upon the formation of nuclei in the kidney which, being passed to the bladder, there grow to sufficient size to prevent their exit from the urethra? Or may they originate in the bladder itself? The latter theory presupposes the presence in the bladder of supersaturated urine, a condition which, I am frank to admit, I cannot conceive except in the presence of alkaline decomposition, a condition which must now be discussed. Alkaline decomposition is due to the infection of the urine with certain organisms which have the power to split urea with the formation of ammonia. These organisms are chiefly pus-forming cocci and the proteus. On the other hand, if the urine be infected with the colon bacillus, tubercle bacillus, gonococcus, and various other organisms, no such decomposition will take place and the urine will remain acid. Alkaline decomposition, on the other hand, renders the solubility of the phosphates of calcium ammonium and magnesium highly precarious and their deposition probable. In fact, so far as they are concerned, the urine approaches a condition of supersaturation and thereby simulates the condition of supersaturation previously referred to under which the formation of crystals may take place in the kidney. But even in the presence of this alkaline decomposition and marked instability of phosphatic salts, stone formation is not altogether a simple process. Thus it is a matter of common knowledge that in some individuals an alkaline

urine may exist for months or years, and no stone form, while in others the slightest change in the reaction of the urine from infection with the pus-forming cocci leads to the deposit of lime salts whether on an ulcer, a foreign body or as a stone. It cannot therefore properly be said that the formation of stone under these conditions is dependent wholly upon the reaction of the urine. The reaction of the urine is undoubtedly an important factor, but it is not the whole condition. Some condition of excretory perversion is clearly necessary. It is therefore chiefly for this reason that I object to the use of the term "secondary" in regard to this form of calculus disease. It is not in a strict sense secondary to infection, though the infection with the resulting alkaline decomposition is clearly an important factor.

An understanding of this reversal of form in calculus disease is necessary to a comprehension of the various layers or laminæ which appear in the stone. Thus the nucleus of a stone may be formed of uric acid or of urates. A considerable overlying layer may be formed of oxalate of lime in an acid urine. Then the irritation of the bladder, the prepared soil, leads to infection, alkaline decomposition takes place, and the succeeding layers of the stone consist of the calcium, magnesium, and ammonium phosphates and the sodium urates varying in proportion. Should the infection subside or the infecting organism change and the urine again become acid, phosphatic deposits will cease, deposits of oxalate may return, and a hard outer layer will then be formed. An extraordinary variety of different layers may exist in any one stone, due to successive changes in the character of the urine.

Composition of Stone.—A stone may consist of any of the substances in the urine which may be precipitated in crystallized form. The commonest are the uric acid or urate, the oxalate of lime, and the phosphatic calculi, which consist of the phosphates of calcium, ammonium, magnesium, and the urate of ammonium, and occasionally of sodium. This list includes stones which occur in an acid and those which occur in an alkaline urine, it being remembered that the reaction of the urine may change during the presence of the stone in the bladder and thereby both varieties of deposits may be found in the same stone. In the acid urine are found the calculi composed of uric acid and urates, calcium oxalate, and the rarer stones of xanthin, cystin and indigo. In an alkaline urine will be found the so-called phosphatic calculi, that is to say, consisting of the phosphate of calcium, ammonium and magnesium, and the urate of ammonium and occasionally of sodium. Stones consisting of pure uric acid are, in this part of the world at least, not common, but uric acid or urates are an exceedingly common constituent of some portion of most stones. Pure calcic oxalate stones are rare, but calcium oxalate is perhaps the commonest constituent of stones found in this part of the world. The rarer variety of stones, that is to say, of those consisting of xanthin, cystin, and indigo, are more likely to be found pure than

are those of the more common variety. Endless discussion has arisen over what constitutes the most common variety of stone. If one is to be guided by the published facts no agreement can be obtained. The observers vary within the widest limits. The explanation of this lies in the fact that different parts of the world show different forms of calculus disease. Thus in a series of 1000 cases of European origin collected by Watson, nearly half show a preponderance of uric acid and urates. More recently collected cases in this country show exactly the opposite, calcium oxalate being by far the most common constituent. These observations can only be reconciled by accepting the facts, as they are irreconcilable. Some of the difficulty, however, has arisen from the failure to distinguish between the nucleus of the stone and the great bulk of the stone. The nucleus is the most interesting if not the most important portion of the calculus. In many analyses no attempt has been made to distinguish between the nucleus and the bulk of the stone, so that we are unable to classify them from this point of view. In these analyses it appears that the stone consists chiefly of the oxalate of lime, with small quantities of uric acid and urates. Now it may well be that these small quantities of uric acid and urates form the nucleus, and therefore the crux of the stone. Until larger series of more careful analyses come to hand the question cannot be solved, but it may properly be asserted now that there is sound reason for believing that the nuclei of many or most stones consists of uric acid or urates. That of those forming in an acid medium the remaining larger portion consists of oxalates, while of those forming in an alkaline urine the bulk consists of phosphates.

Generally speaking, the conditions giving rise to alkaline decomposition are more common in the bladder than in the kidney, and it therefore follows that the proportion of phosphatic stones is larger among vesical than among renal calculi. It may further be said that in the early years of life the conditions giving rise to vesical obstruction are not common. Therefore infection is less likely to take place, and the stones in early life are more likely to be of the acid than of the alkaline variety. The exact opposite is true of those forming in later life. Vesical obstructions due to changes in the prostate or stricture of the urethra are common, infection and alkaline decomposition occur, and the stones are of the phosphatic variety. However, no generalization is safe. Phosphatic stones may be found in early life; uric acid, urate, or oxalate stones in later life.

The Number of Calculi.—Stones in the bladder are more often single than multiple, but we know of no figures bearing upon this point. Not infrequently two, three, four, or five may be found; in rarer cases a very large number—three or four hundred. Where many occur they are almost invariably of small size. Multiple calculi show a noticeable tendency to become faceted, due to rubbing against each other. When a faceted stone is found either by *x*-rays, cystoscopy, or at operation it should be taken as a warning that there must be more,

and a thorough search should be instituted. Multiple stones seem to be more common when there exists sacculation of the bladder.

Consistency and Form.—Stones vary very widely in consistency; the hardest calculi are generally those of oxalate of lime, the softest the phosphatic calculi. Urate calculi are generally fairly hard. Uric acid calculi are often soft. There are, however, great variations, and the density of mixed calculi will depend upon the predominating constituent.

The form of calculi probably depends more upon the shape of the cavity in which they have formed than upon any other one thing. Thus, stones in the bladder are very apt to be round, while stones in the kidney are rarely so, except when they form in a hydronephrotic kidney. Stones which form in a diverticulum of the bladder may show a distinct process when the stone has protruded from the neck of the sac (Fig. 36). They may even take a dumb-bell form, the construction in the dumb-bell occurring at the neck of the sac, one portion lying within the sac and the other within the bladder. Oxalate stones sometimes take very extraordinary shapes, thought to resemble jack-stones, which type is often referred to as jack-stone calculi. The more rounded oxalate stone often has many processes on its surface, from which has arisen the term mulberry calculus. These shapes obviously depend upon the process of crystallization and not upon the cavities in which the stones are formed.

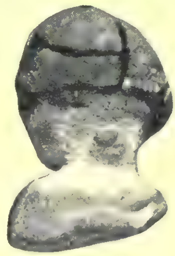

FIG. 36.—Spontaneous fracture of stone in the bladder. The fractured end of this calculus lay within a diverticulum and was protected from mechanical injury. (Watson.)

Color.—Color is an extremely poor guide in attempting to determine the nature of the stone. Phosphatic stones are generally white. Oxalate stones are commonly dark, but the attempt to distinguish between the oxalate stone and the urate stone by color is exceedingly hazardous.

Spontaneous Fracture of Stone.—It has long been known that stone in the bladder occasionally undergoes spontaneous fracture, but the causes of this fracture are even today not well understood. The most reasonable explanation is that the tension within the stone varies with the specific gravity of the urine and possibly with the constituents of the urine. It is also possible that the organic matter within the stone may swell under different conditions, thus forcing the stone apart. Upon this phenomenon depends the occasional reported cases of spontaneous fracture of stone, thought to be due to the miraculous powers of certain drinking waters. Probably it depends not upon the peculiarity of the water but upon the fact that a large quantity having been taken the specific gravity of the urine has been markedly changed, tension in the stone altered, and the fracture has occurred.

Symptoms.—It should be borne in mind that stone in the bladder may exist for a long period without causing any symptoms. This is

more likely to occur when a stone forms in the presence of a residual urine, and lying in a pouch of the bladder does not at any time come in contact with the vesical neck. This is particularly true of stones forming behind the obstructing prostate. A very considerable proportion of these cases have stones which are not discovered except by cystoscopy or at operation. It should perhaps be explained that these patients with urinary obstruction have so much trouble that a little pain more or less is relatively unimportant.

With this proviso it may be said that the commonest symptom of stone is pain and that the most characteristic thing about this pain is that it is increased by motion whether of the individual or of the bladder. Thus it is to be noted that the pain caused by vesical calculus is worse at the end of micturition or when the individual steps suddenly off the sidewalk, rides over a rough road, or turns over in bed. The vesical pain due to stone is, however, in no way characteristic, and the symptoms are precisely similar to those caused by various forms of ulceration at the neck of the bladder, notably such as occur on the middle lobe of an enlarged prostate and in tuberculosis of the gland. Other common forms of genital pain are those referred to the end of the penis, particularly common in children or young individuals, and those referred to the testes, a less common variety. There are also other kinds of pain generally spoken of as referred pains. These are most common in the back, the hip, and occasionally in the heel or sole of the foot. This latter form of interesting pain reminds one of the hero of former times, but far from leading to a process of sulking, it is likely to lead to action. Pain varies in certain pretty definite ways with the age and sex of the individual. In children the symptom of pain may be highly deceptive, perhaps on account of the lack of development of the normal reflexes of the bladder. In these children pain referred to the end of the penis is fairly common, but in many the pain is slight or even absent. The frequency of micturition which ordinarily accompanies pain may be absent and replaced by a condition of incontinence which is very misleading. The most characteristic symptoms of pain due to calculus are seen in adult male individuals, while after the age at which prostatic enlargement commonly occurs the symptom of pain again becomes indefinite and is most likely to be absent. In women there is no noticeable change according to age.

Stoppage of the Urinary Flow in Full Stream.—This symptom consists in the sudden stopping of the flow of urine while the bladder is still but partially empty. It has long been regarded as highly characteristic of stone, and was described in the earlier books as one of the cardinal symptoms. It is due to the sudden forcing of the stone against the internal urethral orifice, and is most commonly seen in adult life without sacculation of the bladder or retention of urine. It must not, however, be regarded as essentially characteristic of calculus, as it may be produced by any condition of ulceration at the vesical neck,

and in my experience has been quite as common in patients with tuberculous prostatitis as in patients with stone.

Frequency of Urination.—This is a constant but not characteristic symptom of stone. It occurs in all conditions associated with or due to inflammation of the bladder. It is more likely to be serious during the day when the individual is up and about than at night when he is in bed, and in this respect is directly the opposite of the frequency caused by the obstructing prostate, which is likely to be most troublesome at night. It is rarely, however, a symptom of importance in diagnosis.

Abnormalities of the Urine.—With very few exceptions vesical calculus is accompanied by changes in the urine. These changes, however, are in no way characteristic, and may vary from the occurrence of a few blood corpuscles and an occasional pus cell to a foul alkaline urine.

Blood in some amount is found in the vast majority of cases, but macroscopic blood is by no means constant. When bleeding in quantities sufficient to be clearly visible in the urine occurs, it is generally terminal in character due to the crowding of the stone against the ulcerated surface. Far more common, however, is the occurrence of microscopic blood which may be said to be the rule. Albumin is generally present and will vary in correspondence with the amount of blood. Pus is present in almost all cases, but when excessive depends largely upon the presence of infection. Aseptic stone in the bladder is rarely accompanied by large amounts of pus. The other extreme is seen in the cases of infection, with the urea-splitting organisms, in which the urine is strongly alkaline and a quantity of mucilaginous material due to the breaking up of pus corpuscles is found in the urine. This material has generally been referred to as mucopus, which is a misnomer. The material is not mucous but gelatinized pus. The character of the urine will give some evidence as to the probable composition of the stone. It will be remembered from the preceding section that in an alkaline urine phosphatic stones will be found while in the acid urine, stones composed of urate and oxalate will predominate.

Priapism.—Priapism is occasionally seen as a symptom of vesical calculus. It is more common in young individuals and in children, in whom it occasionally gives rise to masturbation.

Diagnosis.—The diagnosis of stone in the bladder has been revolutionized by modern methods. Formerly the diagnosis of stone was a highly complicated affair which had been developed into a fine art by those who saw many cases, and long dissertations were written upon the methods of searching for stone. All of these snares and pitfalls have disappeared before the cystoscope and x-rays (Fig. 37). Though the diagnosis of stone in the bladder has thus been simplified it has also been complicated, because with modern refinements of technic has come the increased requirement of accuracy in details. We are

now required to demonstrate not only the presence of stone, but also to discover what other conditions of the bladder or neighboring organs accompany the stone, in order that we may plan subsequent treatment. Today the diagnostician is required not only to demonstrate the fact of stone but also the presence or absence of enlargement of the prostate, tumor of the bladder, or diverticulum, because upon the knowledge of these facts will depend the method of attack.

Fig. 37.—An unusually sharp picture of multiple vesical calculi showing the faceting of the stones and their relation to each other. In the majority of cases no such satisfactory plate can be obtained.

The history and physical examination, including the examination of the urine, will not enable one to come to a decision between stone and many other conditions including the infections of the bladder, particularly with the tubercle bacillus, tumor of the bladder, changes in the prostate, varying from atrophy to malignant disease, diverticulum of the bladder and stricture of the urethra. With this list of possibilities confronting us it is first important to exclude tuberculosis because instrumentation is distinctly objectionable in the genital type of tuberculosis. This condition can generally be excluded by

demonstrating the normal condition of the epididymis and vas and by the absence of characteristic changes in the prostate and seminal vesicles. An acid urine should raise a suspicion of tuberculosis, since with this infection alkalinity is extremely rare. Having excluded genital tuberculosis, the exclusion of stricture is next in order and may be done by the passage of a sound as large as the meatus will admit down to the triangular ligament. Stricture having been excluded the further diagnosis can be made with certainty only by the aid of the cystoscope. It is often a nice question of judgment whether at this stage in the study cystoscopy should be done or an *x*-ray plate taken. As a rule, except in patients with highly intolerant bladders, cystoscopy should be undertaken at this time, since even though stone is demonstrated by the *x*-rays, cystoscopy will be necessary in order to make clear the underlying conditions. If the bladder irritation is so severe as to require the administration of a general anesthetic before cystoscopy can be undertaken and in children too small to be subjected to this treatment the *x*-rays should come at this time. The detection of stone by means of the cystoscope is generally extremely easy. There are few conditions seen with the cystoscope which are more highly characteristic and which look more exactly like text-book pictures. The contrast between the stone and the bladder wall is generally sharp; the phosphatic calculi being white, the other calculi being generally a dark brown and appearing in marked contrast to the red bladder wall. The greatest difficulty lies in the cases of ulcerated newgrowth or various types of benign ulceration in which lime salts have been deposited. A rounded, pedunculated newgrowth covered with lime salts and mucus and a mucus-covered stone may have a striking resemblance. In the more difficult cases the doubt can be cleared up by touching the stone with the beak of the cystoscope. A crusted newgrowth never seems as solid as a stone and will generally bleed upon very moderate manipulation.

But as we have already pointed out, the mere determination of the presence of stone is not sufficient. Therefore examination should be made of the bladder neck in order to ascertain the condition of the prostate, and this should be supplemented by a search for residual urine and by rectal or bimanual examination in order to determine the size and the nature of prostatic change if any exists. Perhaps the most carefully concealed pitfall awaiting the diagnostician in this field is diverticulum of the bladder. If the stone lies in the diverticulum it may be overlooked. If the stone is large it may overlie the diverticulum.

It is important to remember that a stone lying free in the bladder may have had its origin in a diverticulum, and the surface of the bladder, particularly in the neighborhood of the urethral orifices, should be carefully searched for openings which might be those of diverticula. The discovery of a stone which, though not of large size, remains always in one portion of the bladder should also raise

suspicion that it is fixed in this position because part of it lies within a diverticulum. When the stone is of sufficient size to overlie a diverticulum I know of no method by which this trap can be discovered with certainty. It is occasionally possible to roll the stone to one side of the bladder by turning the patient upon his side, but this is frequently a difficult and uncomfortable proceeding.

The *x*-rays have been awarded a more prominent place in the measures of the value of diagnosis of stone than is really warranted. It is in no sense a substitute for the examination of the bladder with the cystoscope because it gives information only in regard to the fact of stone and not in regard to the other conditions upon which the plan of treatment must be based. The practice of taking plates in all cases of stone in the bladder will result in obtaining some interesting and valuable pictures, but is not justified when the expense is of importance. This procedure should be limited to those patients already referred to with extremely irritable bladders or of an age that cystoscopy is impracticable; in a word, to those cases in which the determination of the fact of stone is so important that it justifies the neglect of the more careful and systematic procedure. In this connection it should be remembered that the detection of stone in the bladder by means of the *x*-rays is very much less certain than is that of stone in the kidney. For some reason which is not now clear many stones in the bladder are overlooked by this method, a proportion far larger than in the kidney. For this reason a negative *x*-ray must not be taken as certain evidence of the absence of stone.

In women vaginal examination will frequently enable the surgeon to feel the stone; always if it is of considerable size. Rectal examination in the male is of much less value and will rarely detect a stone with certainty. When neither the *x*-rays nor the cystoscope is available the method previously employed of searching for stone may still be used. Searching for stone is nothing more nor less than the attempt to touch the stone with a metal instrument to which a peculiar feeling is thereby imparted. Many different forms of stone searchers have been invented which have a distinct advantage over the ordinary steel sound, in that they are of smaller caliber and have a much shorter beak, and can therefore be passed to the bladder with less discomfort. When the stone lies in a bladder which is able to empty itself completely it can generally be felt without difficulty, and will impart a characteristic grating sensation to the instrument. Errors are most often due to calcareous deposits around the neck of the bladder such as are occasionally seen in tuberculosis and more frequently in an encrusting cystitis due to alkaline decomposition. Sometimes the tough fibrous tissue of a contracted prostate may yield a very misleading sensation. Probably the great majority of stones which are overlooked by this method are, however, those which lie in a pouch behind the enlarged prostate. When there is a residual urine the search should be prosecuted first, with the bladder normally distended,

then the urine should be withdrawn with a catheter, which may have the effect of making the stone more readily accessible to the instrument. When, however, all is said and done, stones lying in a post-prostatic pouch will not infrequently be overlooked by this method, and it is for this reason that the method of examination with the cystoscope is so clearly superior to that with the searcher.

Treatment.—Treatment may be considered under three headings:

1. Prophylactic treatment.
2. Medicinal treatment.
3. Operative treatment.

PROPHYLACTIC TREATMENT.—If the word prophylactic means anything it means treatment which is intended to, and does in fact, strike at the causes of the condition. This involves a knowledge of the fundamental causes of stone, of some of which we are as yet entirely ignorant, namely, of the chemical conditions within the body which give rise to supersaturation and consequently to crystalline deposits. In the present state of our knowledge we cannot prevent the formation of the nucleus.

With the mechanical conditions which play a considerable part in the growth of stone we are to some extent familiar and can therefore to that extent prevent more growth. These mechanical conditions are retention and infection. The most common causes of retention are changes in the prostate, stricture of the urethra, diverticulum of the bladder, and lesions of the nervous system, giving rise to enervation with retention. There should also be added the relaxation of the anterior or vaginal wall in women, giving rise to cystocele and in some cases to slight retention. When any of these conditions exist, stone in the bladder is far more likely to occur than under normal conditions, and their correction is desirable for this if for no other reason. As we have already pointed out, infection of the bladder with the urea-splitting organisms leading to alkaline decomposition is an important factor in the formation of phosphatic stone. This infection, therefore, should be combated, and we have at the present time an effective method of doing so by the use of the Bulgarian bacillus. This has been nicely worked out by Caulk, and is described in his article upon cystitis. We shall have further occasion to refer to this method in the prevention of recurrence of calculi.

This is perhaps the proper place to refer to the importance of seeing that all attacks of renal colic which result in the passage of a stone to the bladder also result in the passage of the stone from the bladder. If, following an attack of renal colic, nothing is seen of the stone a cystoscopic examination is indicated, for should the stone be allowed to remain in the bladder it is almost certain to increase in size, and any operation for its removal becomes to just that extent more difficult.

MEDICINAL TREATMENT.—By medicinal treatment we mean the administration of drugs, having for their purpose the solution of stones

which have already formed. An infinity of drugs have been tried for this purpose, chiefly following the view that alkaline solutions tend to dissolve acid salts, and conversely that acids tend to dissolve alkaline salts. Many medicinal waters have been advised, and the proprietors of various health resorts have grown rich and corpulent, but evidently any real solvent effect upon stone still lacks demonstration. The error in all these calculations has lain in the fact that chemical processes which take place in the test-tube cannot be reproduced in the human body. Thus drugs given by mouth must be passed into the intestinal tract, be taken into the blood and excreted by the kidney, their action thereby becoming highly uncertain. That sojourns at health resorts have benefited patients with stone is not to be denied, but the benefit has not been in the solution of the stone. A few cases of spontaneous fracture have undoubtedly occurred, but as we have already pointed out this is more likely to be due to the drinking of water than to the drinking of any particular water or to the use of any particular form of diet. "Since Pliny's ashes of snail-shells even to the present day the wise and the foolish alike have searched unceasingly for something which, taken by the mouth, might be capable of dissolving a stone in the kidney or the bladder, and the substance has not been found. The Joanna Stephens remedies worked wonders in the last century, until Parliament bought the secret for £5000, after which they quickly fell into disuse and are now forgotten. Each of the four patients whose cures were attested by the trustees appointed by the Government to investigate the matter died with stone in the bladder, as proved by autopsy." (Keyes, Sr.)

Evidence is lacking at the present time to show that we have any control or any means which will enable us to dissolve stones which have already formed, with the possible exception of certain phosphatic deposits dependent upon alkaline decomposition, a question which will be later discussed.

Operative Treatment.—The operative treatment of stone in the bladder is one of the most fascinating chapters in the history of medicine. That operations were attempted in the very early days of history and probably before the Christian era is evidence at once of the severity of the symptoms and of the comparative accessibility of the bladder as compared with other abdominal viscera. It is also a commentary upon the courage both of the patient and of the surgeon. The earliest accurate description of these operations is given us by Celsus, of the School of Alexandria. The operation in brief consisted in the pulling down of the stone toward the perineum by the finger in the rectum. An incision was then made directly upon the stone which was extracted with forceps. Apparently the incisions were made vertically, transversely, laterally, and bilaterally. This was known as the "apparatus minor," because very few instruments were needed in its performance. Celsus states that the operation was suited to children below the age of fourteen. Eginus describes a similar opera-

tion, using only the lateral incision, and does not state that it was limited to any particular age.

Following this there is a long silence which may be due to the fact that the operation was not brilliantly successful or that the records have been lost. In 1533 Marianus described an operation which was original with him, and which followed in general the lines of the previous operation in that it was of the perineal type. It was a great improvement, however, in that a staff was introduced into the urethra and facilitated the accuracy of the incision, which was made in the median line, probably dividing the tissues of the bulb. The deeper portions of the urethra were then dilated or stretched with a branched dilator or with a gorget. The stone was then extracted by means of various kinds of forceps. This operation was picturesquely called the "apparatus major," apparently because of the great variety of instruments which were or might be used. This operation had very considerable limitations because it only dilated or divulsed the deeper portions of the urethra, and therefore rendered the extraction of large stones difficult. The tortures of the patient during the process of dragging even moderate-size stones through the partially dilated prostatic urethra may readily be appreciated.

Early in the eighteenth century Frére Jacques modified the operation by making a lateral incision, though he still employed the guide in the urethra. This operation gave very much better access to the stone, and with some modifications by Cheselden developed into the modern operation of lateral lithotomy. While the perineal operation was thus developing its precarious career, the suprapubic route, or as it was commonly called, the "high operation" was also brought forward. It was always attended with much greater risk, probably because of the danger of opening the peritoneal cavity or of getting extensive suppuration in the prevesical space. In the long run it never had the same vogue in the preantiseptic days as did its older brother the "low operation" and was generally reserved for very large stones which could not be readily dealt with below. It is of course to be remembered that none of these operations were undertaken except upon patients who were suffering the tortures of the damned, and were willing to undertake any risk provided it offered some probability of relief.

The Development of Crushing Operations.—The development of operations having for their purpose the breaking up or crushing of the stone by instruments introduced through the urethra belongs wholly to the nineteenth century. In 1824 Civiale produced an instrument with three branches, straight in construction which, introduced through the urethra, grasped the stone and a drill was then passed through the handle of the instrument and the stone bored into. He successfully demonstrated before large audiences that a stone could be broken into fragments by this method. In the same year Weiss showed an instrument with two blades, between which the stone was grasped.

In 1832 Heureteloup introduced an instrument with two blades, one riding upon the other, a great advance over the instrument of Weiss. The difficulty with the earlier instrument lay, among other things, in the fact that the male blade tended to ride away from the female blade, and becoming dislocated, made the instrument impossible of extraction. Some tragic cases in which this accident occurred and necessitated a lithotomy led to the development by Costello of a male blade which traveled in a groove in the female blade from which it could not be dislocated. In these earlier instruments the crushing force was applied by a hammer upon the projecting end of the male blade. Charriere and Thompson developed a screw handle by which the compressing force could be developed by means of a thread screw. These instruments had many defects. They were of comparatively light construction and could be used only upon soft stones. The operations were generally done in several stages or sittings, it being believed that these sittings should not last more than a few minutes. The fragments broken off from the stone were passed by the patient during the subsequent days, and when the irritation resulting partly from the operation and partly from the fragments had subsided another sitting was undertaken.

Evacuators in various forms were tried in rather a half-hearted way, but never were in great favor, largely because they were grossly inefficient. Matters stood thus when in the seventies of the nineteenth century Bigelow, of Boston, took up the problem. Being a mechanical as well as a resourceful genius, he promptly put his finger upon the weakness of these operations by pointing out that the injury to the bladder by fragments was more than the injury by the instrument. In some of his earlier communications he discusses in considerable detail the probability of doing serious injury to the bladder by the proper use of properly constructed, smooth steel instruments and contrasts it with the inevitable injury resulting from sharp fragments of stone driven against bladder wall by the contractions of that organ. The amount of time spent while the patient was under efficient ether anesthesia he declared to be far less important than the complete removal of all the fragments. The part which Bigelow actually played in the development of the operation of litholapaxy, which properly bears his name, has been much misunderstood. By some it is believed that he invented the operation of crushing stone. By others it is thought that he is the first person to use an evacuator. Neither of these facts is at all correct. The lithotrite has been in common use for more than half a century. Evacuators of various kinds had been tried and discarded. It remained for Bigelow, the mechanical genius, to perfect the details both of the lithotrite and of the evacuator, so that they became efficient and mechanically correct. The lithotrite he modified as to its size, the shape of its blades, the mechanism of the handle, and the lock. The pump he modified as to the shape and size of the evacuating tube and as to the method of strain-

ing the fragments so that they did not wash in and out of the bladder. It would probably be correct to say that he introduced no essentially new principle unless it be the possibility of passing large, straight instruments through the prostatic urethra even in face of enlargement of the prostate. The credit for the demonstration of the possibility of passing large instruments through the deep portions of the urethra undoubtedly belongs to Fessenden Otis.

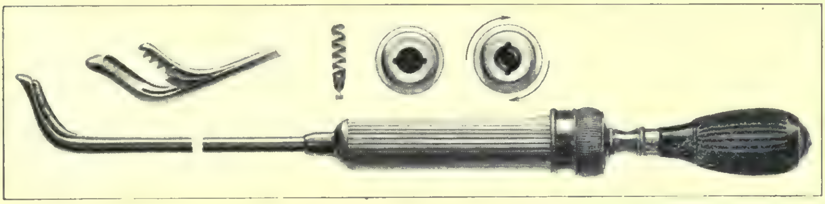

Fig. 38.—Bigelow's lithotrite. Note the turned-over tip and the low rim of the female blade and the lateral discharging notches of the male blade. The mechanism and shape of the handle is well shown.

The Lithotrite.—Bigelow's lithotrites were considerably larger and heavier than any that had previously been employed. They were criticised by Keyes as clumsy, to which Bigelow replied that as it was his intention to crush stones much larger than had previously been dealt with, it was therefore desirable to have instruments of sufficient size and strength to deal with the largest and hardest stone. Although today it is rarely necessary to use the largest lithotrite that Bigelow produced, it is to be remembered that we are rarely dealing with stones as large as were comparatively common at that time.

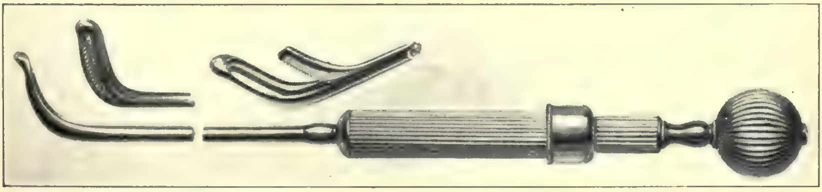

Fig. 39.—Bigelow's lithotrite. An earlier model showing a large fenestra in the female blade, a more rounded tip and the narrow and possibly dangerous male blade. The handle is of the earlier round type which he later discarded.

The Blade.—Bigelow insisted that the blades of the lithotrite should be placed at right angles to the shaft and that the tendency hitherto considerably apparent of placing the blades at a slight angle tended to make their crushing force less efficiently applied. The female, or receiving blade, he made stronger, gave it a lower rim, particularly at the heel, where, as he pointed out, clogging was most likely to occur (Figs. 38 and 39). The tip of the female blade he turned over slightly in such a way as to prevent the possibility of picking up the bladder

wall, an accident which had not infrequently occurred with the earlier instruments, and which might prove of serious consequence. A fenestrated female blade had been commonly employed, and to this Bigelow at first objected, but in his later instrument came to employ it as a more satisfactory method of clearing the heel of the blade. The male blade he provided with triangular notches which discharged laterally, thereby throwing fragments outward and further, avoiding the great danger of clogging. This matter of clogging had perhaps been the most serious about previous instruments, as should it become impossible to thoroughly close the blades the withdrawal of the

FIG. 40.—Detail of the jaws of a modern instrument miscalled a Bigelow lithotrite. Note the high rim of the female blade and the certainty of more or less clogging.

lithotrite was necessarily accompanied by serious lacerations of the urethra, which occasionally resulted in organic stricture (Fig. 40). As his operations were necessarily prolonged, and as it was part of his principle to remove the lithotrite and to introduce the evacuating tube after a certain proportion of a large stone had been crushed, and as it often became necessary to remove and reintroduce the lithotrite three, four, or even five times, it will readily be seen that an instrument which would completely clear itself became of prime importance (Fig. 41).

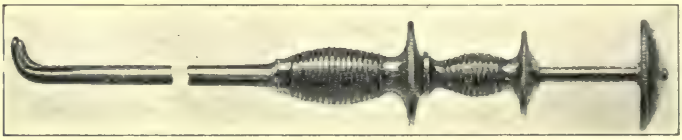

FIG. 41.—A small lithotrite without much power, useful for children and for extracting foreign bodies.

The Handle.—The handle of the lithotrite in common use in Bigelow's time was of the wheel type, as shown by the French instruments and particularly by the instrument of Sir Henry Thompson, which was in most common use (Fig. 42). Bigelow showed that this wheel was an uncomfortable instrument for use during a long operation. He modified it at first by making it spherical (Fig. 39) and later egg-shape (Fig. 38), peculiarly fitted to the palm of the hand. In this, as in many other instruments which he perfected, he showed a clear appreciation of the importance of having an instrument lie comfortably in the hand.

The Lock.—The locks in use at that time all necessitated the removal of the hand from the end of the instrument in order to manipulate them. This seemed to Bigelow an unnecessary waste of time and strength, and he invented a lock which was directly under the control of the fingers of the right hand without removing the palm of the hand from the handle of the instrument. He saw at once that the simplest action of the hand was in rotation, and his lock was made to work by a simple rotation of the forearm (Fig. 38).

The Evacuator or Pump.—Many years before Bigelow's time evacuators had been tried and almost entirely abandoned, the most important candidate for favor having been the evacuator of Clover. Their position, however, was aptly summed up by Sir Henry Thompson, who said that they had been abandoned in his practice because they were inefficient. They had, in fact, always been discarded because they removed only the finer dust from the crushing and soon became clogged by the larger fragments. Backed by the then recently enunciated

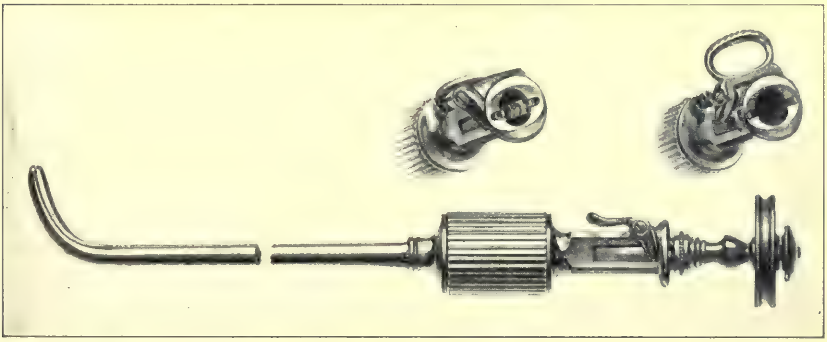

FIG. 42.—A lithotrite with the French lock, wheel handle and faulty jaws.

doctrine of Otis that the urethra had a normal caliber of 32 French, except at the meatus, Bigelow introduced very much larger tubes and preferred those ranging from 28 French to 31 French. In this way the process of evacuation was very much shortened, as was also the process of crushing the stone because the very much larger fragments would pass through the larger tube. He further brought out the fact that a straight tube could be passed with perfect ease to the bladder and was a more effective evacuating instrument. We are today all of us familiar with the doctrine then first enunciated by him, that in passing straight, or nearly straight, rigid instruments to the bladder they should be passed backward toward the rectum as far as they will go and that the turn into the long access of the body should not be made until the extreme bottom of the bulb has been reached. The process of passing the membranous and prostatic urethra was aided by a boring or rotary motion, which, though it seemed likely to do damage to the prostate, did not in fact do so. In the production of a

satisfactory evacuating pump he made many models, and though the first model introduced by him with his lithotrite in 1878 was a very great improvement over previous evacuators, his final and most successful model was not completed until 1883. It consisted of a large, stout rubber bulb with a rounded glass bulb upon the bottom into which the fragments fell, and through the walls of which they could readily be seen. A strainer was introduced within the cavity of the bulb, thus materially shortening the width or size of the instrument. He placed a stopcock upon the upper extremity of the bulb, to which was attached a tube through which water could be sucked in from a receptacle at one side of the table. He further added a stopcock at the point where the bulb joins the evacuating tube, so that both the tube and the bulb could be closed and no water spilled when the bulb was disconnected from the tube. Bigelow's work upon this instrument occupied a considerable part of his spare time from 1875 to 1883, and during that period he made many publications in America, England and France, and finally obtained complete acceptance of his doctrines, which were at first more or less violently opposed.

We are now, after the lapse of thirty-seven years, in a good position to estimate the permanent value of Bigelow's achievement. During that period practically every operation in surgery has been more or less completely revolutionized. The whole understanding of aseptic surgery has come into being, and the safety with which cutting operations can be undertaken has enormously increased. Moreover, inventive genius has been applied to instruments for the exploration of the bladder, and the cystoscope with the enormous advances which it has rendered possible has come into general use. Many modifications of Bigelow's lithotrite and his evacuator have been attempted, and yet it stands today, both the lithotrite and the evacuator, on precisely as firm a base as it did thirty-seven years ago. No important or permanent change has been made and no important addition has been made to the essential facts which he enunciated in his original papers. The work is a lasting testimonial to his mechanical genius and monumental patience. I believe that I am within the facts in stating it to be the most remarkable single achievement of American surgery.

Modifications of Bigelow's Instrument.—As early as 1884 Chismore, of San Francisco, feeling the need of an instrument which would more certainly pick up the last fragment, added to the handle of the lithotrite a rubber bulb for the purpose of producing suction. In order to do this he tunnelled the shaft of the instrument and to a considerable extent modified the shape of the blades. He at first advised its use only for the purpose of obtaining the last fragment, but as time went on he extended its use in his own practice until he came finally to employ it in practically all cases. In the hands of other operators, however, it has not proved a satisfactory instrument, and so far as I can learn has never been successful except in the hands of its originator. With the introduction of the cystoscope came the very natural desire

to combine the lithotrite and the cystoscope, partly in order that the operation might be carried out under vision, but more importantly that the certainty of catching and crushing the last fragment might be increased. Instruments combining the cystoscope with the lithotrite have been produced by Nitze, Casper and Walker. They have all of them, however, been adapted chiefly to small stones and in no way occupied the position of Bigelow's instrument. It remained for Young, of Baltimore, to attempt to combine the ideas of Bigelow, Chismore and Nitze and to produce a lithotrite which was at once able to evacuate fragments and would accommodate a cystoscope. This instrument he first described in 1910. It was a large instrument, No. 28 of the French scale, and followed in general the ideas laid down by Bigelow, which he properly regarded as basic and superior to others who had followed him. The general shape of the jaws is that of Bigelow, but he has abandoned the curving over of the tip of the female blade which Bigelow regarded as important and which seems to me to considerably facilitate the passage of the instrument. The shaft is made tubular, having an internal caliber of No. 25 French, which thus corresponds to a good-sized straight evacuating tube, and the heel of the instrument is fenestrated as in some of Bigelow's later instruments, but the fenestra is carried downward and is large and round to accommodate the passage of the cystoscope. The general types of the handle and lock are those of Bigelow, with minor changes in the nature of the grip. The handle ends in a cap which, when removed, opens the end of the evacuating tube to which the evacuating bulb and a small receiver for fragments can be attached. Through this same channel, when the cap is removed, the cystoscope is passed. The evacuator, both as to form and construction, is much superior to that of Chismore. It is a very ingenious, well-made instrument, and is of value for small and medium-size stones. It seems to me, however, to be what one might call a fair-weather instrument, and I should strongly suspect that it would fail in the management of large, hard stones. For such stones it is dangerously weak at the point where the vast majority of lithotrites constructed upon principles other than Bigelow's have failed, notably at the point where the female blade joins the shaft. At this point, in order to admit the evacuating channel No. 25 French, it is thinned out to the greatest possible extent, and I believe to an extent which is positively dangerous. Furthermore, for use upon large stones, an evacuating tube of No. 25 French is too small. The cystoscopic attachment seems to me of doubtful value. In the easy cases with small stone and comparatively clean bladder the introduction of a cystoscope after the removal of the lithotrite is a matter of no difficulty. In the difficult cases of large stones in highly inflamed bladders the medium almost certainly becomes cloudy and can rarely be made sufficiently clear to make the operation of cystoscopy worth while. This is generally better carried out at a subsequent sitting. That this instrument recently enthusi-

astically proclaimed by Kelley to introduce a new era into litholapaxy will really do so no one familiar with the operation of Bigelow will believe.

Lithotomy.—Having traced the development of litholapaxy down to the present time, it only remains for us to follow the development of a cutting operation into the modern era. Though the perineal operations of median and lateral lithotomy were developed far earlier, and were the most numerous in the early days, they did not long survive the appearance of the era of aseptic surgery. As operative surgery became a relatively safe business the advantages of the suprapubic route, the old *sectio alta*, became more apparent. The perineal operation was at best a blind, bloody business, never well adapted for the management of large stones, and having a considerable liability to damage the structures of the bladder neck and occasionally of the rectum. With the disappearance of the fear of peritonitis and of serious infection of the prevesical space, the suprapubic route at once came to its own. By this method there is no damage to structures other than the bladder, and that portion of the bladder which is traversed by the operation is a relatively unimportant one. Moreover, it gives ample opportunity for inspection of the interior of the bladder and for the study and, if necessary, operative treatment of conditions other than stone, notably tumor, adenomatous enlargement of the prostate, and diverticulum.

The Choice of Operation.—In selecting an operation for the treatment of stone in the bladder we need at the present time to consider only two methods, namely, litholapaxy and suprapubic cystotomy. In making the selection the following points must be considered:

1. The relative safety of the operation.
2. The certainty of cure.
3. The minor but still important questions of discomfort to the patient, duration of confinement, and possibility of complications.

Before entering upon this discussion it may be well to point out that the two operations are subject to different limitations. Suprapubic cystotomy is applicable to any patient, large or small, young or old, while litholapaxy can be applied only to the patient whose urethra is passable or can safely be made passable to satisfactory instruments. For this reason small children and larger children with large stones are not proper subjects for litholapaxy. Moreover, litholapaxy concerns itself wholly with the stone and is inapplicable to patients having any condition in the bladder other than stone which requires operations. With these limitations in mind the two operations can be compared.

The Relative Safety.—"Of all the operations that are or have been employed in the treatment of stone in the bladder, litholapaxy when properly performed is generally conceded to be the safest and most brilliant. In support of this proposition it is only necessary to adduce the authority of Cabot and Chismore in this country, of Thompson

and Harrison in England, of Guyon in France, and of the entire school of Indian surgeons who alone see more cases of stone than all the rest of the world put together." This quotation from Keyes, written many years ago, is equally true today, and has never been seriously disputed by any surgeon whose experience renders him competent to express an opinion.

As regards actual mortality, neither of these operations should in competent hands be accompanied by any notable risk. The deaths which occur are almost exclusively due to conditions other than the stone, notably to damaged conditions of the kidney, which would give rise to a fatal termination in any operation or even when no operation is performed. What difference there is is clearly in favor of litholapaxy, since any cutting operation exposes the patient to some, though a comparatively small, danger of infection, which will occasionally prove fatal. Moreover, the confinement to bed following cystotomy is enormously greater than that required by litholapaxy, and this alone may be a factor in determining a fatal issue.

The Certainty of Cure.—The probability of cure of stone in the bladder depends far less upon the nature of the operation than upon the condition which caused the formation of the stone. Thus no operation will influence that ill-defined thing, the tendency to stone formation. No operation will prevent the descent of stone from the kidney forming nuclei for new vesical calculi. Neither operation has any notable advantage over the other as affecting the infection of the bladder with urea-splitting organisms which result in phosphatic deposits. Therefore the certainty of cure depends entirely upon the certainty of entirely removing the stone. It is undoubtedly true that in unskilled hands suprapubic cystotomy is more certain to leave the bladder entirely clean than is litholapaxy, but properly performed litholapaxy followed by cystoscopy is quite as certain in its results as is the high operation. It may therefore be said that so far as the certainty of cure is concerned, with the limitations of the operation as above laid down, the results are equally good. Thus the choice of operation will ultimately turn upon the consideration mentioned in our third subheading above.

Discomfort.—As regards the relative amount of suffering following these two operations there can be no comparison. The results are wholly in favor of litholapaxy.

The discomforts of suprapubic lithotomy are those of the average laparotomy, which involves a drained wound, and are probably better appreciated by the patient than by the surgeon. Those who believe that any abdominal operation is free from discomfort are commended to the delights of sneezing or coughing against abdominal sutures. As compared with this the discomfort following litholapaxy is that attendant upon an inlying catheter, which is never in place more than three days, and is frequently removed in one. Thus the balance in this most important particular, that of confinement to the hospital,

is wholly in favor of litholapaxy, and this is a question which is peculiarly likely to be uppermost in the mind of the patient. The complications of suprapubic lithotomy are those incident to a drained wound, since it is practically never safe to entirely close the wound. Only in favorable cases can the bladder wall be closed and drainage left down to that layer. Thus, even under the most favorable conditions there is a portion of the wound which is not tightly closed and must heal by granulation. Under more unfavorable conditions in the face of considerable bladder infection, drainage of the bladder itself must be instituted, with a considerable increase in the probability of moderate degrees of wound infection. When the infection is more than moderate it constitutes a complication which may prolong the stay in the hospital for one or two weeks beyond the ordinary, and which will then leave the patient with a persistent sinus, though generally not a urinary sinus, which may persist for some weeks longer. It is by no means infrequent that these patients have some trouble with their wound for a period of two months or even more.

The complications of litholapaxy are those incident to an inflamed bladder, namely prostatitis, epididymitis, and if catheter drainage must be prolonged, urethritis. Prostatitis as a complication is today rare as compared with former times, when a considerable proportion of the patients upon whom litholapaxy was performed had large prostates, and would today be subjected to prostatectomy and not to litholapaxy. The probability of stirring up a prostatitis in a prostate substantially normal may be regarded as slight. Epididymitis is probably the most important complication of litholapaxy and is a direct result of the mild grade of prostatitis incident to the inlying catheter. The incidence of epididymitis is difficult to state. It is certainly not over 10 per cent. and is more probably in the neighborhood of 5 per cent. It is an uncomfortable but never a serious complication, rarely prolongs the stay of the patient more than one week, very rarely leads to abscess and pays no permanent Irish dividends. Again the balance is in favor of litholapaxy. To sum up the question of the choice of operation, litholapaxy is the operation of election for all uncomplicated stones in the bladder not having a foreign body as a nucleus and in which the proper instruments can be passed. Suprapubic lithotomy is the operation of election in all cases where there is known to be, or may be, any other condition in the bladder demanding operation. For instance, to elect litholapaxy in the presence of an enlarged prostate which ought to be removed is bad surgery. To crush a stone in the presence of a diverticulum, in which the fragments may be lost or from which another stone may start, is to invite recurrence, an invitation which is generally accepted. By the same token, to do suprapubic cystotomy for a stone which might perfectly well have been crushed is an improper disregard of the rights of the patient. It is unfortunately a fact that suprapubic lithotomy is today the operation of choice with a very large number of surgeons in this

country. This choice is not made because it is the operation of election, but because it is the operation with which that particular surgeon is familiar. It relieves the patient of his difficulties at an expense in time, money and discomfort which is quite unjustifiable.

LITHOLAPAXY.—In the days when Bigelow popularized the operation of litholapaxy there was very little choice in anesthetics. In most parts of this country ether was always the anesthetic of choice, while throughout the whole country the only choice was between ether and chloroform. Today we have a very much broader field from which to choose, and the surgeon is in every case required to have his reason for his choice to account for the faith that is in him. In general the choice is between local anesthesia, which in this case means an anesthetic applied to the urethra and to the bladder mucous membrane, and general anesthesia, which may be held to include spinal and sacral anesthesia.

Local Anesthesia.—Broadly speaking, local anesthesia is suited only to the management of small stones in relatively tolerant bladders. Practically it is most commonly used for crushing small calculi which have come down from the kidney but which are yet too large to pass from the bladder and to the crushing of small recurrent stones which have been discovered early. In my hands, at least, local anesthesia has proved unsatisfactory for dealing with stones of moderate or large size or in relatively intolerant bladders. The greatest amount of discomfort results from the use of the evacuator. The crushing may be satisfactorily carried out, but the repeated distention and contraction of the bladder by means of the pump has been extremely uncomfortable with any local anesthetic which I have used.

Drugs.—Cocain has been generally abandoned, owing to its relatively high toxicity. Its place has been taken by the newer synthetic compounds, novocain, tropacocain, stovain, and alypin. Of these novocain has seemed to me the most reliable and satisfactory. Tropacocain seems to be somewhat less potent as an anesthesia and stovain has seemed to me more toxic. In producing anesthesia of the urethra and bladder in the male it is to be remembered that the deeper portion of the urethra from the triangular ligament to the internal urethral orifice is by far the most sensitive. It is also noteworthy that absorption of the drug from the reasonably healthy mucous membrane is slow and but partial. Particular attention should therefore be paid to the prostatic urethra. Two methods of producing anesthesia of the prostatic urethra are in common use: (1) one by the injection of fluid into the urethra with the hope that a certain amount of it will remain in the prostatic portion, (2) or by the direct placing of the tablets of the drug in the prostatic urethra by means of an instrument provided for the purpose of which the tablet depositor of Bransford Lewis is perhaps the most serviceable. If the solution is to be used a 5 per cent. solution of novocain should be introduced into the prostatic urethra through a soft-rubber catheter which has been

passed to the bladder and then slightly withdrawn. It is always a matter of some guesswork as to how much remains by this method. If the tablet depositor is preferred the tablet is placed in the instrument, which is then introduced into the prostatic urethra, the obturator is pushed home, and the tablet is left in the urethra. Anesthesia of the bladder itself has been in my hands a most uncertain business, and I have generally not undertaken to produce it. If it is desired to make the attempt, 1 or 2 ounces of a 1 per cent. solution of novocain should be introduced into the bladder. In any case a period of at least five, better ten, minutes should be allowed to elapse between the introduction of the anesthetic and the beginning of instrumentation.

General Anesthesia Including Spinal and Sacral Anesthesia.—The choice of a general anesthetic will depend largely upon the physical condition of the patient and most largely upon the condition of the kidneys and of the lungs. The kidney function has with us been tested by the phenolsulphonephthalein method of Rountree and Geraghty, which has given complete satisfaction. While ether is probably still the anesthetic most generally used, its greatest qualification is clearly that it is the most nearly fool-proof of all general anesthetics. It is clearly undesirable in damaged conditions of the lung and in damaged conditions of the kidney, both of which will be found with great frequency with patients with stone in the bladder. In my own practice I have practically abandoned ether as a general anesthetic except when some other more desirable method could not be used. With chloroform I have had but little experience, but it is clearly not to be preferred to ether so far as the kidney function is concerned. For most operations in the presence of damaged kidneys, nitrous oxide and oxygen seems to me the anesthetic of election. For the operation of litholapaxy, however, it has the disadvantage that it causes marked congestion of the urethra and bladder, which result in more bleeding and consequently more clouding of the medium. This is, however, not an important objection, and I regard it as the anesthetic of election among the general anesthetics.

Spinal and Sacral Anesthesia.—These methods have one great advantage over the general anesthetic in that they affect the terminal nerve endings in the bladder and abolish the bladder reflex, thereby increasing the bladder capacity of irritable bladders, which is under certain circumstances a very great advantage. This is particularly true of the contracted, highly intolerant bladders, into which under ether or nitrous oxide anesthesia only a very small amount of fluid can be introduced. This amount may be so small as to seriously hamper the movements of the instrument, and under these circumstances the moderate increase of capacity given by spinal or sacral anesthesia is a very great advantage. Were spinal anesthesia known to be or proved to be a thoroughly safe method of anesthesia it would undoubtedly be the anesthetic of election. This position it has not, however, yet achieved. In the hands of most of us it has proved uncertain, and even though

we have had no fatalities, we have seen some cases in which a nearly fatal issue has apparently been due to this method. The dangers of spinal anesthesia, as ordinarily employed, I believe to be due to the occurrence of splanchnic paralysis. This will occur only when the anesthetic involves the dorsal nerve roots, as recently shown by Porter and Smith. It therefore follows that it is a more or less dangerous method of anesthesia when it is desired to obtain anesthesia in areas supplied by the dorsal nerve root. For this reason we have abandoned it for operations above the pubes. For perineal operations and for intravesical operations done through the urethra only anesthesia of the lumbar and sacral nerve roots is necessary. I have come to believe that when properly administered spinal anesthesia can be limited substantially to the lumbar and sacral nerve roots and that it is therefore the anesthetic of election in many cases of perineal and intravesical operations. Our present technic is as follows: The patient is placed in a sitting position across the operating table and made to lean forward, arching the back toward the operator. The space between the spines of the third and fourth lumbar vertebræ is identified and marked. This area is anesthetized by injecting a small quantity of 1 per cent. novocain into the skin and the deeper tissues including the interspinous ligament. The "spinal needle" is then introduced into this anesthetized area and pushed steadily forward in the middle line, inclined moderately upward until the slight resistance of the dura covering the cord is encountered. The obdurator of the needle is then withdrawn and the needle pushed forward until there is a flow of spinal fluid. The syringe containing 1 c.c. of anesthetic solution is attached to the needle and 1 c.c. of spinal fluid is drawn into the syringe, which then contains only 2 c.c. of total fluid. The injection is then made moderately slowly and needle withdrawn. This method we have now used in a large number of cases and it has uniformly given us perfect anesthesia of the bladder and urethra in about ten minutes and having a duration of from one hour to an hour and a quarter. It is freely admitted that there are a certain number of elderly patients with stiff backs into whose spinal canals we are unable to enter and who must therefore be regarded as a failure by this method. Sacral anesthesia is a somewhat newer candidate for favor, and in the hands of those who have used it most has given excellent results. My personal experience has been rather unfortunate. I have frequently been unable to produce complete anesthesia, in some cases no anesthesia at all, and in others only a patchy or partial anesthesia. This I believe to be chiefly due to faulty technic, and I am prepared to believe that with better development of technic it can be made universally successful. Should this be the case it is preferable to spinal anesthesia because not open to the same objections.

Preparation of the Patient.—The preliminary study of patients regarded as suitable to litholapaxy should include especially a study of the kidney function, of the bladder capacity and of the peculiari-

ties of the urethra. Since these bladders are to be subjected to a considerable strain in the process of evacuation it is important to know accurately what is their ordinary or average capacity. Thus a bladder which becomes intolerant after the injection of four ounces should not be overfilled during the process of evacuation or rupture may possibly occur, though it is only fair to say that I have no personal knowledge that this accident has ever occurred in competent hands. If the urethra is the site of false passages, their exact location should be known beforehand so that they may be avoided. Should a stricture exist rendering the passage of instruments up to at least No. 28 French impossible, it will have to be cut as a preliminary to litholapaxy, though under the same anesthesia. Should the stricture be in front of the bulb, internal urethrotomy is appropriate. Should it be of the bulbar type, perineal section must be done and a perineal litholapaxy may then conveniently be carried out.

The Introduction of the Lithotrite.—If the bladder capacity is normal, 100 to 150 c.c. of 2 per cent. solution of boric acid should be introduced through a catheter. If the bladder is of less than normal capacity it should be distended to the point which has previously been ascertained to be safe. Some question may arise as to what constitutes the smallest amount of fluid in which litholapaxy can be properly performed. This will depend in the last analysis upon the skill of the operator. Personally, I should hesitate to attempt litholapaxy with a distention of less than 50 c.c., though I have seen skilled operators, such as the late A. T. Cabot, carry out a satisfactory litholapaxy with evacuation in two ounces of fluid. A lithotrite should be selected suitable to the size and probable hardness of the stone. The hardness can perhaps best be estimated by the shadow cast on the *x*-ray plate. For large, hard stones a full-sized lithotrite having a caliber of about No. 28 French should be selected. For medium-sized stones the medium-sized lithotrite is appropriate. For children the largest lithotrite which the urethra will take should be selected. For right-handed surgeons a position upon the left side of the patient should be selected for the passage of the instrument. "South paws" should take the right side. If the meatus is too small to admit the instrument readily it must be cut. In passing a lithotrite to the bladder the maneuver is somewhat different from that which is used in introducing an ordinary, curbed steel sound, as the short beak of the lithotrite as contrasted with its long handle makes it unusually likely to get caught either above or below the opening of the triangular ligament. The well-lubricated lithotrite having been introduced into the meatus, it is pushed steadily forward while held in a vertical position until the beak reaches the lowest part of the bulb. If the handle be depressed before this point is reached the beak of the instrument will catch in front of the opening in the triangular ligament. If, on the other hand, when the instrument has reached the bulb the turn is sharply made, the beak of the instrument may catch below the triangular ligament.

A maneuver which will generally render the passage of this opening easy is the lifting of the heel of the instrument by the fingers of the left hand placed in the perineum. The beak will then be felt to jump over the depression below the triangular ligament, and at that time, if the handle of the instrument be rapidly depressed, it will slide easily forward into the bladder. The mistake is occasionally made of believing that the lithotrite has reached the bladder when in fact the beak rests in a dilated prostatic urethra, a condition which is not uncommon in later life. This mistake may be avoided by being sure that the beak of the instrument can be turned freely from side to side. If it is in the prostatic urethra it can be turned, but not with freedom.

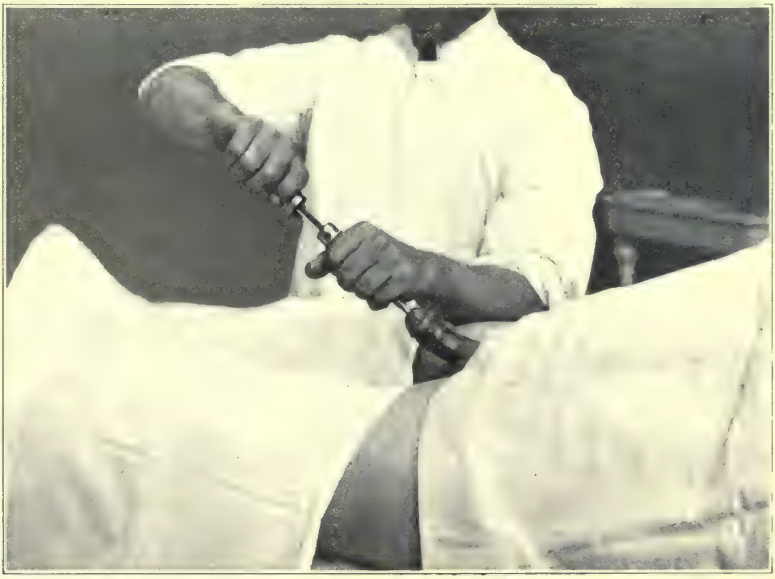

Fig. 43.—The method of holding the lithotrite at the beginning of the operation of crushing.

When the instrument has reached the bladder the handle should be entrusted to an assistant while the surgeon goes to the other side of the table, since during the process of crushing he should always stand upon the patient's right side, unless, as above suggested, he is left-handed. When standing upon the patient's right side the handle of the lithotrite just below the lock is grasped firmly in the left hand, which acts during this part of the operation only to steady and brace the instrument; in fact, is a support or crutch, and takes no active part in the crushing (Fig. 43). The handle of the instrument should then be raised so that the heel depresses the floor of the bladder while the shaft comes up under the pubic arch. Into this depression the stone will roll or gravitate so that it can be readily caught in the jaws of the

instrument (Fig. 44). The heel having been depressed, the jaws are opened to the fullest extent possible in the amount of distention existing. In the most favorable cases the stone will roll between the jaws and be at once caught, when they are pushed home (Fig. 45). Should it not be thus caught the jaws should be again opened strictly in the middle and then turned first to one side and then to the other.

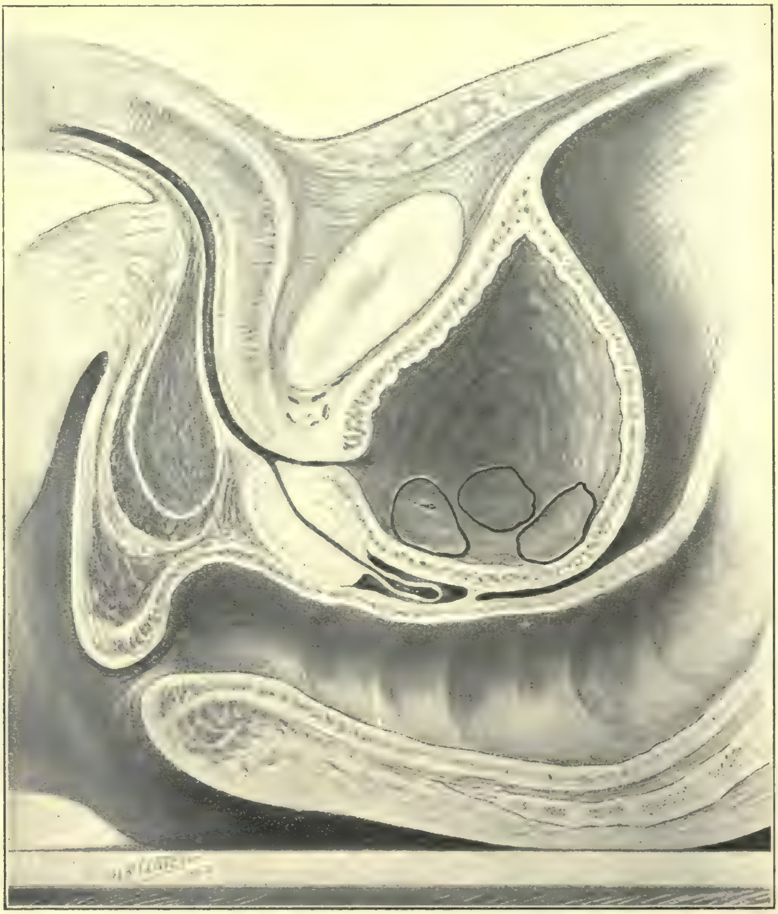

Fig. 44.—This sketch shows possible positions which a stone might occupy unless a groove or pouch were made in the bladder floor.

Should neither of these maneuvers engage the stone it is because it lies either below or above the instrument. It will lie below the instrument in cases of prostatic enlargement, with a considerable retroprostatic pouch (Fig. 46). If this is the case the instrument should be opened again strictly in the middle line and the jaws then turned over so as to reach into the pouch (Fig. 47). This has been regarded

as a dangerous maneuver, but with jaws shaped according to the pattern of Bigelow and the bladder reasonably well distended it is impossible to pick up the bladder wall. Should the search of the retroprostatic pouch fail to discover the stone it is because it lies above the instrument. This will occur when the lower segment of the bladder is narrow, either by thickening of the wall or by enlargement of

FIG. 45.—The first maneuver for catching a stone.

the prostate, so that the stone is too large to be grasped by the jaws opened to the extent which that condition of the bladder will allow. Under these circumstances it has often been thought that the stone was attached to the upper wall or that it was so light as to float. Neither of these conditions in fact exists. If it lies above the instrument it may be caught by the following maneuvers: The handle of the instrument is lowered between the patient's thighs until it lies in

the long axis of the body. The jaws can then be opened to a considerably larger extent, and if the handle be further depressed, any stone lying above the instrument can be grasped.

The stone having been caught in the jaws the lock is fastened, the handle of the instrument lowered into the median line, and the lithotrite then turned from side to side or pushed forward and backward

FIG. 46.—The stone in this case is inaccessible to the lithotrite held as in Fig. 45.

to be certain that the stone is not caught in a pocket and that no mucous membrane is attached to it. Only when this freedom of motion has been ascertained should the jaws be screwed home by turning the handle. Frequently a stone will be caught not in its greatest diameter and the first crushing will break off only a corner of the stone. In fact, the second application of the lithotrite, or even the third, may give the impression that another and larger stone

has been grasped. It is in fact only a larger diameter of the same stone. After the stone has been caught two or three times and broken into large fragments the process of pulverizing it, often referred to as "munching," should be carried out with the handle elevated and the heel depressed. In this position the larger fragments will constantly fall between the jaws of the instrument and complete subdivision of

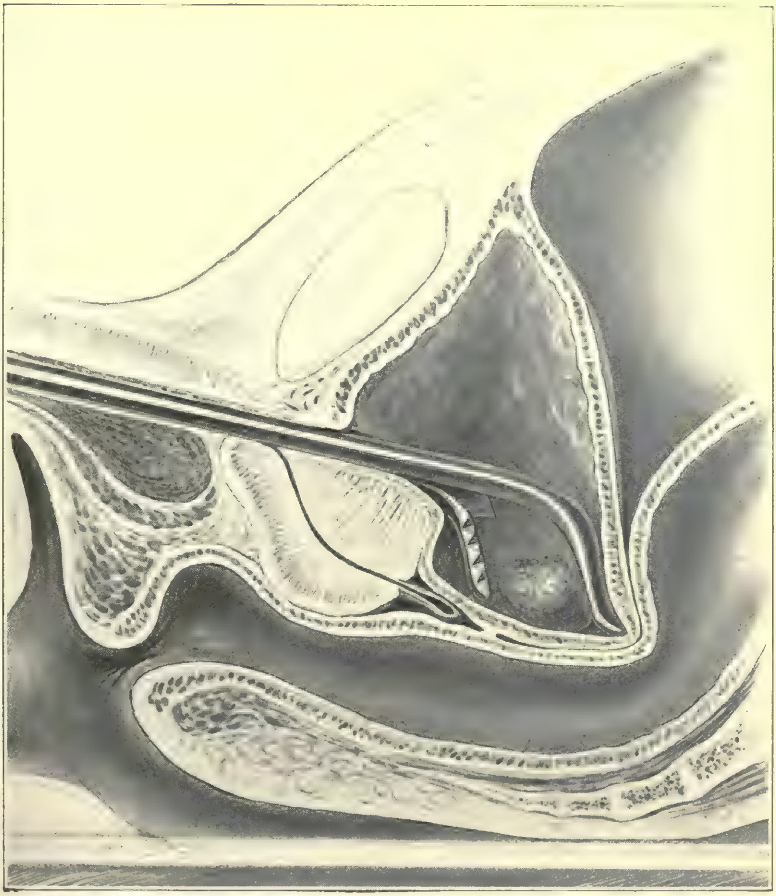

Fig. 47.—Method of grasping stone when conditions in the bladder are as shown in Fig. 45.

the stone is generally possible. This process of munching should be continued until no fragment of any size can be caught between the jaws. The process of powdering up the stone between the male and female blades should be carried out somewhat differently when a Bigelow lithotrite is used than when one is employed with a fenestrated female blade. The Bigelow female blade having no fenestra, the male

blade can be pressed down upon it with the right hand and need not be screwed home, as there is no possibility of the instrument clogging. On the other hand, the fenestrated blade will force some fragments out through the heel of the instrument, and if the jaws are not brought closely together these projecting fragments may seriously lacerate the posterior bladder wall. With the fenestrated instrument therefore it is important to see that the blades are fully closed each time they are brought together.

In the process of pulverizing large stones the amount of débris may become so considerable that even large fragments cannot be caught between the jaws. When such a condition occurs the lithotrite should be withdrawn, the excess of detritus washed out, and the further crushing then completed. In withdrawing the instrument it should be brought into the middle line and the jaws closed. If they do not come absolutely together it is because some fragments, generally of almost cement-like débris, still lie between the blades. If the attempt is made to withdraw the instrument not fully closed, laceration of the urethra will occur. Complete freeing of the instrument may be obtained by screwing it firmly home and then opening and closing it several times until the sensation of metal against metal is conveyed to the fingers. If it seems to catch at all in the prostatic urethra it is probably because the jaws are not exactly in contact, and it should be returned to the bladder, opened and reclosed, until complete contact exists; the lithotrite can then be withdrawn without lacerating the urethra.

The Evacuation of Fragments.—An evacuating tube should be selected which is as large as the urethra will take. If the stone has been of considerable size a tube of at least No. 28 French is necessary unless the operation is to be unnecessarily prolonged. A straight or nearly straight tube will evacuate the largest fragments with the greatest ease. A tube with a slightly Coudé point is more easily passed. The curved tubes more closely following the curve of the ordinary steel sound are considerably easier of introduction, and for small stones are satisfactory.

Before introducing the tube the stopcock should be fitted to it so that the fluid will not be withdrawn from the bladder. If a straight tube has been selected it should be passed directly backward to the bulb, then lowered into the horizontal plain and pushed forward. If it catches at the orifice of the triangular ligament a slight boring or rotary motion may be employed. This maneuver was, I believe, first introduced by Bigelow and, though it is somewhat terrifying to the novice, may be safely employed in skilled hands. When the eye of the instrument has reached the bladder it should be allowed to rest slightly above the base. The bulb of the instrument thoroughly filled with water with the stopcocks closed should then be fitted to the tube. The two stopcocks upon either side of the joint where the bulb and tube meet should then be opened so that the air in the tube runs

backward into the bulb and rises to the top. The stopcock between the bulb and tube is then closed, the cock on the top of the bulb opened and the bulb compressed so as to force out the air which has entered the bulb and fill it entirely with water. The cock at the top of the bulb is then closed, all cocks leading to the bladder are opened and evacuation is begun (Fig. 48). At the beginning of evacuation the eye of the tube should lie slightly above the base of the bladder. If it is pushed deeply into the base it is likely to become embedded in fragments which may quickly clog the eye and render evacuation difficult. At first the bulb should be compressed with rather rapid short strokes and the eye of the instrument should be maintained in one position as long as fragments come freely through it. When the

FIG. 48.—The method of holding the pump at the beginning of evacuation.

supply becomes meager the tip of the instrument should be depressed into the base of the bladder and the process continued. Fragments too large to come through the eye will give a sharp click, a sound quite unmistakable when once felt or heard. If the stone has been large it is probable that the first crushing has not sufficiently pulverized it to render complete evacuation possible. Under these conditions several fragments too large to come will be left and from these repeated clicks will be felt. It not uncommonly happens that a fragment too large to come through the tube catches in the eye and remains there. This will be appreciated when the compression of the bulb becomes difficult and it refills slowly after compression. Generally a fragment thus caught will soon disengage itself. Should this not occur

the bulb should be disconnected and the fragment pushed out of the eye with a stylet. It occasionally happens that a fragment thus caught is jammed in such a way that it cannot be readily disengaged by a stylet. It has been my experience that fragments caught in this way are small fragments which will not scratch the urethra if the tube is withdrawn while they are still in position. This, however, is a maneuver not to be undertaken if the fragment can be disengaged with a stylet. If it has been necessary to use a stylet in order to pry out a fragment thus caught the bladder will necessarily have been emptied and the fluid must be replaced before evacuation can be continued. This is generally best done by attaching the bulb, compressing it until a satisfactory amount of water has been injected into the bladder, then closing the stopcock on the tube, opening that upon the top of the bulb and allowing the bulb to refill from the vessel containing the fluid. The evacuation should then be continued until one of two conditions presents itself. Either nothing comes through the tube and the bladder is believed to be free from fragments or a comparatively small amount of dust comes and nothing but clicks are obtained. Under these latter conditions the tube should be withdrawn and the lithotrite reintroduced. With stones of the size ordinarily encountered today two applications, or two introductions, of the lithotrite are generally sufficient. With the second introduction of the lithotrite every effort should be made to make the crushing complete. This means that the lithotrite should first be employed as in the first crushing, then should be carefully turned first to one side of the bladder then to the other and finally should be turned with the jaws toward the base and the base of the bladder carefully searched for fragments of any size. With increasing experience the probability of having to introduce a lithotrite a third time will decrease except in the presence of unusually large stones. When the crushing is believed to be complete the lithotrite is again removed and the tube reintroduced. The procedure on the second occasion is the same and is concluded with the search for the last fragment. In the search for the last fragment the eye of the tube should be carried to all parts of the bladder base and suction made so as to engage any fragments that exist. A helpful maneuver consists in turning the instrument upside down so that the eye is pointed toward the bottom of the bladder, in which position the bulb is sharply compressed. Any fragments lying in the depth of the bladder will then be forced upward and if the eye of the tube is then turned around they will be caught coming down. It is in this search for final fragments that the phenomenon of the bladder wall coming against the eye of the instrument is most likely to be felt. This consists in a peculiar tap against the instrument which has been spoken of as resembling a fish nibbling at a line and is therefore often referred to as a "fish bite." If this occurs only when the eye is closely applied to the bladder wall it has no particular significance. If, however, it occurs with the tube in various portions of the

bladder it means that there is considerable laxity of the bladder wall and that the bladder therefore is not sufficiently distended. It is most likely to occur toward the end of the evacuation, when a certain amount of the fluid has come out around the instrument or been lost in the various manipulations. Should the evidence be that the bladder is not sufficiently distended a larger amount should be thrown in from the bulb which is then refilled to capacity. With this final search of the bladder with the evacuating tube the operation as described by Bigelow ended. Even, however, in the most skilful hands a fragment, generally small, was occasionally left behind and had to be later removed, or if not removed became the nucleus of a fresh calculus. The modern operation therefore includes a final examination with the cystoscope. In most cases this can be satisfactorily carried out immediately after the evacuating tube is removed. In some cases the amount of oozing of blood from the prostatic urethra will be so great that a satisfactory medium cannot be obtained. Should this be the case the cystoscopy should be postponed for a few days until a thoroughly satisfactory medium can be had. The picture of a bladder from which a stone has just been removed requires some explanation. It is very red, the mucous membrane is much thickened, often thrown into folds which when close to the eye of the instrument may look not unlike the surface of a newgrowth. The fact, however, that they are not much elevated above the surface can be appreciated by slightly raising the end of the instrument so that a better perspective is obtained. There are also generally to be seen areas of whitish phosphatic deposit upon the bladder wall where ulceration has taken place. These areas may be mistaken by the novice for fragments but they will readily be seen to be flat and not to have the angular appearance characteristic of a fragment of stone. For the purposes of this examination a cystoscope of full size and having a large field of vision should be selected. If a fragment has been left it should be crushed at once. If the bladder is empty the operation is completed by a final washing out of the bladder and of the prostatic and pendulous urethra and, in most cases, by the placing of an inlying catheter. The decision for or against drainage of the bladder with an inlying catheter will be influenced chiefly by two considerations. First, by the amount of inflammation of the bladder and infection of the kidney and second, the amount of trauma of the urethra and perhaps even of the bladder itself, due to the operation. Thus where the stone has been of considerable size and has therefore probably been in the bladder for some time, there will be much infection and probably infection of the kidney. Such a case should certainly be drained. Opposed to this is the case of the small stone recently descended from the kidney lying in a comparatively healthy bladder. Such a case will probably do perfectly well without drainage. The amount of trauma to the bladder or urethra can be estimated accurately by the amount of blood in the fluid filling the bladder. Thus if there is a moderate tinging of the

water, some trauma of the prostatic urethra may be assumed; infection at the site of this trauma is probable, and drainage is desirable. On the contrary, a practically clear bladder fluid in a bladder but slightly infected is an indication to omit drainage. A safe principle for these cases is the following: When in doubt, drain.

After-treatment.—The after-treatment of these cases consists in seeing that the drainage through the catheter, if one has been employed, is well maintained in the administration of large amounts of water, of efficient urinary antiseptic, and in the maintenance of an acid urine. The maintenance of efficient drainage in these cases is of first importance and this requires thorough knowledge of the management of the inlying catheter. Should it fail to drain regularly intermittent retention will occur and no advantage exist over the entire omission of drainage. The management of the inlying catheter, though not difficult, requires constant supervision and the surgeon who cannot command the assistance of skilled nurses or orderlies will do well to leave this department of surgery to others. Nowhere is skilled nursing more essential to success.

Of the urinary antiseptics those containing formalin are entirely superior to any others but their use has been less efficient than it might have been because their management has not always been thoroughly understood. They are wholly dependent for their action upon the maintenance of a considerable degree of acidity. In an alkaline neutral or faintly acid urine they are a failure, manufacturers' testimony to the contrary notwithstanding. Furthermore, their excretion by the kidney is fairly rapid and a given dose is generally entirely excreted in between four and five hours. For this reason their administration three times a day is grossly inefficient. The dosage should be regulated not by the advice of the manufacturers, the size of the patient, or the whim of the surgeon, but solely by the evidence of the amount of formaldehyd actually excreted by that particular patient. A few tests will serve to show the behavior of the drug in each case. If the dose is too small the amount of formaldehyd in the urine will be little or none. If the dose is too large vesical irritation will probably result. Between these two extremes a balance must be struck.

The maintenance of an acid urine is, as suggested above, of prime importance. An alkaline reaction is due in the great majority of cases to infection of some one of the urea-splitting organisms of which the most common are the pus cocci. These are practically unaffected by any of the formaldehyd-containing preparations and the urine will remain alkaline in spite of such efforts. In the past it was customary to combat this alkalinity by the administration of drugs by mouth, chiefly boric acid and the benzoate of soda. Both of these were, however, frequently inefficient and were quite as likely to upset the digestion of the patient as the reaction of the urine. It has recently been shown by Caulk that these cocci can be controlled and the reaction

of the urine made acid by the introduction of the Bacillus bulgaricus directly into the bladder.

A considerable experience with this method has satisfied me that it is extremely difficult. The urine can be maintained at an acid reaction, the formaldehyd compounds given by mouth are properly broken up in the bladder and the coccus infection satisfactorily controlled. This holds good however, only in those cases in which the coccus infection is of the bladder and not of the kidney. If the urine is broken up and rendered alkaline by infection of the kidney the introduction of the Bulgarian bacillus into the bladder will not affect the reaction. This latter condition is, however, comparatively infrequent and we have come to regard the method of Caulk as a highly important adjunct in treatment. There are some patients who, though they have no infection with urea-splitting organisms, still normally have a slightly alkaline, neutral or faintly acid urine. This condition must be corrected if the urinary antiseptic is to work properly. As already mentioned, boric acid and benzoate of soda are more or less objectionable for this purpose. It has been shown by Smith and others that the acid phosphate of sodium is very efficient and has none of the objections above mentioned. It also has the added advantage that it is a valuable, mild cathartic.

Confinement to bed after the operation of litholapaxy will depend entirely upon the length of time during which the bladder drainage with the inlying catheter seems desirable. This in turn depends upon the rapidity with which the bladder infection quiets down. In the worst cases it may be necessary to maintain drainage for a week or even ten days. In the milder cases forty-eight hours is sufficient. The confinement will also of course be influenced by the occurrence of complications.

Complications. Bleeding.—Bleeding is rarely a complication of importance in these cases. When it occurs the blood comes almost always from a more or less injured prostatic urethra, a condition which the inlying catheter will most rapidly allay. The most common inconvenience caused by bleeding is the occurrence of small blood clots which clog the eye of the catheter and interrupt drainage. This must be carefully watched for and should it occur frequent irrigations of the bladder will prevent it. In rare cases the bleeding may be so sharp as to cause an amount of clogging which entirely stops the drainage and cannot be overcome by irrigation. Under these conditions the bladder may fill with clots and cause serious difficulty. Should this occur and evacuation of the clots through the catheter be shown to be impossible two courses are open. The mildest and therefore the best is the introduction of one of the smaller tubes of the Bigelow evacuator and the evacuation of the clot by means of the pump. Should this fail there is no alternative except to open the bladder, which should be done without hesitation. It may be said, however, that in a fairly large experience including cases not only of my own but of many other surgeons I have never known this to be necessary.

Prostatitis.—In any condition of bladder infection a mild degree of prostatitis may have existed before the operation. Should this be the case a certain amount of stirring up by the operation is highly probable and it may possibly go on to the formation of a prostatic abscess. This, however, is certainly rare. The milder grades of prostatitis are not particularly uncommon. They show themselves by a moderate amount of fever, some enlargement and tenderness of the prostate as felt by rectum. The treatment is that of prostatitis from any other cause and consists chiefly in the maintenance of good drainage and in the use of hot rectal irrigations.

Epididymitis.—This will occur as a complication in a comparatively small number of cases and always in connection with some degree of prostatitis. The most important question which the occurrence will raise is as to the desirability of continuing urethral drainage. On general principles this would seem highly undesirable as tending to increase the prostatitis and thereby the epididymitis. It has been by no means clear to me that the continuance of the catheter in the urethra has any effect upon the progress of the epididymitis. Certainly it is not today in my hands a sufficient reason for removal of the catheter if clear indication for continuance of urethral drainage exists. In general, however, if the condition of the bladder is such that the catheter may safely be removed it is better to do so. The management of its infection differs in no respect from infections of the epididymis from other cause, a snug bandage, such as that of Alexander, heat or cold (heat has worked best in my hands) and continuance of rest in bed. As a complication it is sometimes very annoying, as it requires confinement in bed for a week beyond the ordinary period. In rare cases suppuration of the epididymis will be of sufficient extent to require incision and drainage. This has not, however, in our cases been common.

Peri-urethritis.—If the urethra has been small and the instrument has been large some trauma to the interior urethra is not uncommon. This occasionally gives rise to infection and peri-urethritis. This will show itself as an indurated patch most commonly at the penoscrotal angle, occasionally in the bulb, which may go on to the formation of a considerable mass. In most cases it will subside on removal of the catheter. In some cases incision may be necessary. Its management does not differ from that of peri-urethritis from other cause.

Fever.—Though fever is of course only a symptom of some underlying condition it is yet of sufficient interest to be worthy of separate discussion. Fever is characteristic of most of the complications already discussed. It occurs in some degree in prostatitis, epididymitis and peri-urethritis. There is, however, a very considerable group of cases in which none of the above-mentioned conditions can be demonstrated to exist and in which fever still is the most predominating symptom. In these cases the physical examination may be entirely negative. At first one naturally thinks of an intercurrent pyelo-

nephritis as the most probable cause of this condition but nothing in the physical examination or in the examination of the urine points with any certainty to this condition. Costovertebral tenderness is commonly absent, the urine though pus-laden and filled with bacteria is not importantly different from the condition existing before the fever began. Some recent work by my resident surgeon, Dr. Crabtree, has led me to believe that this is a septicemia most commonly due to the colon bacillus. Blood cultures undertaken shortly after the occurrence of fever have generally been positive for the colon bacillus. With this there may or may not be an accompanying pyelonephritis. Under favorable conditions the bacteria are secreted by the kidney, or rather excreted, without important damage to those organs. The diagnosis of this condition can only be made by the most searching examination. Other complications causing fever must be carefully excluded. The most difficult of exclusion is the quiescent type of pyelonephritis. This can generally be detected by the sharp drop in kidney function. This presupposes, of course, a fairly accurate knowledge of the kidney function before operation and perhaps after operation before the occurrence of the unexplained fever. The diagnosis can only be made with certainty by the finding of a positive blood culture. The bacteria probably reached the blood either from the traumatized bladder wall or from the infected prostate. The picture is that of a symptomless fever. To recognize the condition is of considerable importance, for should it be confused with a prostatitis and the catheter thereupon withdrawn from the bladder the condition will undoubtedly be made more serious and the probability of infection or increased infection of the kidney thereby increased. The indications for treatment are the continuation of bladder drainage with particular care that it be well maintained, the administration of urinary antiseptics, with particular care that they be properly broken up, and watchfulness of the condition of the circulation. Particularly in elderly patients we have seen many cases in which the heart action was considerably weakened under the strain. Whether this strain was due to the direct action upon the heart muscle or indirectly to damage to the kidney cannot be said, but in many of the cases it has been necessary to apply cardiac stimulation often with some skill and generally with great benefit. This type of septicemia may last for many days or even weeks but our experience has not led us to regard it as a frequently fatal complication. It is not notably more likely to occur after litholapaxy than after any operation upon the infected bladder.

Cystotomy.—It will be unnecessary to discuss the various methods or types of cystotomy which not many years ago would have required considerable discussion. The perineal operations of medial and lateral lithotomy are today of only historical interest. They have properly been discarded because they did not meet the indication. The supreme advantage which cystotomy has over litholapaxy is that it enables the

surgeon to deal with conditions other than stone which exist within the bladder. This is true, however, only of suprapubic cystotomy except insofar as the operation of perineal lithotomy enables the surgeon to deal with the enlarged prostate. By the perineal route newgrowths and diverticula not only cannot be dealt with but their presence cannot with any accuracy be determined. It is therefore safe to assert that suprapubic cystotomy is the only common method in use today. Probably in the majority of cases in which a stone is removed from the bladder through a suprapubic wound the removal of the stone is only a part of another operation such as prostatectomy or excision of the diverticulum. In these cases the removal of the stone is a mere incident to the operation and no description of the technic of these operations need be gone into here. As already pointed out, suprapubic cystotomy is indicated for the removal of stone in those cases in which litholapaxy is contra-indicated. Briefly stated, the indications are as follows:

1. For all cases in which there exists in the bladder some condition other than stone requiring operation.
2. For children too small for litholapaxy.
3. In cases of a large stone in a contracted bladder.
4. Where stone has formed about a foreign body.

SUPRAPUBIC LITHOTOMY.—*Anesthesia.*—Much that was said under the heading of Anesthesia when describing the operation of litholapaxy is applicable here except that we have come to believe that spinal anesthesia is not satisfactory for these cases for reasons above discussed, but by the same token local or infiltration anesthesia is highly satisfactory. Its use is, however, considerably circumscribed. In the hands of most surgeons it is not readily applicable to children and there will be a considerable number of cases of large stone in contracted irritable bladders in which the anesthesia cannot be made satisfactory. In skilled hands, however, it is frequently the method of election. Of the general anesthetics ether is objectionable, as above stated, in all cases in which there exists damage to the kidney. It therefore follows that of this group of anesthetics nitrous oxide and oxygen is the most valuable.

The Operation.—The bladder should be filled to capacity, which capacity should be ascertained before anesthesia with a 2 per cent. solution of boric acid. This solution is, we believe, superior to salt solution or sterile water in that it inhibits bacterial growth to some extent and is less likely to allow of wound infection when the wound is flooded with the bladder fluid, as it must be when the bladder is opened. In some cases of contracted irritable bladders, practically no fluid can be introduced and the operation must be done as in an almost empty bladder. The incision should be a low, median incision with its lowest end below the top of the pubic bone and its upper extremity three or four inches higher, according to the thickness of the abdominal wall. The incision is deepened until the properitoneal fat

is reached, at which time the interest centres in the avoidance of the peritoneal cavity. At this point in the operation it has been the practice of some surgeons to make the incision directly against the pubic bone, thereby separating any adhesion which may exist between the peritoneal fold and the pubes (Fig. 49). This method I have come to regard as highly objectionable since it invades the periosteum of the pubes and in a few cases has in my hands led to a definite infection of the pubic joint giving rise to a troublesome type of infectious arthritis which has been very disabling to the patient. It has resulted in a definite looseness of the pubic joint which looseness generally

Fig. 49.—The incision in the periosteum of the pubic bone which may be accidental or intentional is here shown. The peculiar appearance of the bladder wall due to the presence of veins in the muscular coat is highly characteristic.

results in pain referred down the thighs and occasionally to the region of the sacro-iliac joint. It is strikingly similar to a type of disability not infrequently seen in women following a difficult labor but is generally not thought of as a complication of a suprapubic operation. It has, however, with us been a serious matter in a few cases and we now scrupulously avoid the periosteum of the pubes. The danger of opening the peritoneal cavity has been a bugbear to this operation for many years. It may, however, safely be regarded as similar to other bears, more important in the books than in practice. Though it is a not infrequent accident it occurs almost exclusively when its possi-

bility has been forgotten or disregarded. In the moderately distended bladder the anterior fold of the peritoneum lies almost or quite in contact with the posterior border of the pubic bone. If the fingers of the right hand are pushed gently down behind the pubes and the tissues overlying the bladder are pushed upward, a definite fold will be felt to roll under the fingers and the unmistakable structure of the bladder wall will be exposed. The appearance of the bladder wall is unlike that of any other structure in this neighborhood. It is a definitely muscular structure having veins upon and in its substance (Fig. 49). When such a structure is seen it may safely be incised as being the bladder wall. When the bladder wall is identified it should be fixed in some way. Many surgeons insert one or more sutures as stays on either side of the incision but this has seemed to us an unnecessary complication and we simply use a pair of catch forceps on either side of the point at which it is intended to open the bladder. As the bladder wall is incised the cut ends of the muscular bundles will retract and finally the smooth mucous membrane will bulge into the wound. At this time the knife with the edge turned toward the pubic bone, not upward, should be thrust into the bladder and the fluid allowed to come out alongside of it. If the knife is simply entered and then withdrawn it is sometimes a little difficult to pick up the edge of the mucous membrane and a few moments' time may be lost. If the knife is left in position the wound can be slightly prolonged downward; it should not be prolonged upward for fear of nicking the peritoneal fold. When the fluid has largely drained from the bladder the edges of the bladder wound should be picked up with catch forceps and the finger introduced. The size, shape and possible multiplicity of the stone should be determined. The stone should then be removed with the forceps which, though they were made subsequent to fingers, are more likely to remove the stone intact. The stone having been removed, a careful search of the bladder should be made for fragments broken off from the surface of a single stone or for small stones remaining if larger ones have been removed. It is surprisingly easy to overlook a small supplementary calculus. When all fragments or stones have been removed the interior of the bladder should be carefully explored with the finger to eliminate the possibility of a diverticulum and to ascertain the condition of the prostate. A newgrowth previously undetected may occasionally in this way be found. The bladder condition having been satisfactorily dealt with we are in the position of Hamlet. To drain or not to drain, that is the question. It must be decided in much the same way as after the operation of litholapaxy. Septic bladders should be drained, comparatively clean bladders need not be drained above the pubes. However, the majority of cases to which suprapubic cystotomy is applicable will require suprapubic drainage. The bladder wound should be closed from below upward, the tube being placed at the upper angle of the wound so as to bring it as far as possible away from the pubic bone. It was formerly regarded as important that

sutures in the bladder wall should not pass through the mucous membrane and should not, therefore, enter the cavity of the bladder itself. The reason for this fear was that calculus formation would take place about the sutures. This fear was, however, only justified in those cases with an alkaline urine in which the tendency to phosphatic deposits was very great and was of course rendered more probable by the fact that very permanent material, generally silk, was used for this purpose. The fear of introducing sutures into the cavity of the bladder is, I believe, today without foundation. Phosphatic deposit will only take place in an alkaline urine. This alkaline urine can be controlled. If it is not controlled, recurrence of the stone is inevitable, and it makes comparatively little difference whether it begins about a suture, about a blood clot, or about the slight ulceration upon the edge of the wound. The important points about a satisfactory suture of a bladder wound are that the edges of the muscles should be brought together broadly, that there should be some inversion of the bladder wall about the tube and that the closure should be so snug that no leakage takes place. The inversion of the bladder wall about the tube produces the effect of a valve so that when the tube is withdrawn prompt closure takes place. This principle was first clearly brought out by Gibson. I now employ a continuous suture of catgut beginning at the lower angle of the wound going through all the layers of the bladder wall up to the tube at the upper angle. At this point the suture should be tied but not cut and with the same suture the bladder wall should be inverted over the suture line already taken and about the tube. The suture goes down to the lower angle of the wound and is finished by tying the beginning to the end of the suture. If it has been thought safe to close the bladder without the introduction of a tube the suture is carried the full length of the incision, going from below upward and then from above downward. When this method has been employed it is always wise to leave some drainage down to the bladder wall. For this purpose we employ the rubber-like material generally sold under the name of protective tissue. Gauze is unnecessary and undesirable. The closure of the remaining portions of the wound is similar whether a tube has been left in the bladder or drainage simply left down to the bladder wall. The bellies of the recti should be caught loosely together and the fascia closed with interrupted catgut sutures. It is of some importance that this suture be made carefully, as a very considerable number of cases of hernia following this operation have come to our attention due, as we think, frequently to careless suture, occasionally to wound infection. If the bladder has been closed without suprapubic drainage an inlying catheter should be placed in the urethra before the operation is finished.

After-treatment.—The importance of the establishment and maintenance of an acid urine is even greater after suprapubic lithotomy than after litholapaxy. An ammoniacal urine seriously interferes with

nice wound healing, and in fact kind healing can hardly be expected in the presence of such a urine. Moreover, the wound offers a most desirable site for the phosphatic deposits which so readily take place under these conditions and such deposits are exceedingly frequent. The maintenance of a satisfactory degree of acidity of the urine is probably the most important single factor in a satisfactory wound healing. For this we have come to rely chiefly upon the measures suggested by Caulk and now regularly introduce into the bladder immediately after operation the Bulgarian bacillus and see that its presence is maintained throughout convalescence.

The Management of Drainage.—If the bladder has been drained with a tube the management of this tube will require considerable nicety of judgment. It is obviously important that this tube should be removed at the earliest moment compatible with safety. Its presence in the wound for several days results in a stiffening of the wound and a much more persistent urinary fistula. If a good degree of acidity of the urine has been obtained I believe it to be safe to remove the tube as soon as the tissue layers have become sealed and thus shut off. Such a point should be reached certainly in forty-eight hours and in favorable cases in twenty-four or thirty-six. The tube having been removed two courses are open: Either the urine may be allowed to drain into the dressing or an inlying catheter may be placed in the urethra and the wound allowed to close rapidly. On this point there is a square division in the practice of surgeons today. One group believes that the use of an inlying catheter exposes the patient to considerable danger of inflammation of the prostate simply from the mechanical presence of the catheter and that the cystitis is not only not relieved but probably increased by this fact. The other group believes that the presence of the inlying catheter does not in fact seriously complicate the situation, that the inflammation resulting from its presence is very generally superficial and that the rapidity with which wound healing can be obtained is of the first importance. Moreover, from the point of view of the patient at least the constant presence of a urinous poultice is a distinctly detrimental factor. It is my own opinion that the constant presence of a wet dressing not only interferes seriously with wound healing but exposes the patient to serious danger of surface chilling and greatly prolongs convalescence. It is my own practice always to place an inlying catheter when the tube is removed. In the presence of an acid urine leakage from the suprapubic wound will often cease during the first twelve hours and should never after that time be an important factor. If it is thought best not to employ the inlying catheter very frequent change of dressing becomes essential. In most cases it will be necessary to change the dressing at least once in two hours day and night and this requires the constant attendance of a skilled nurse. This condition of wet dressing will persist at least a week, generally ten days, not infrequently two weeks, and becomes a serious strain upon the patient.

If an inlying catheter has been placed in position the situation becomes practically similar to that which exists in those cases in which it has been thought wise to close the bladder at once and place an inlying catheter at the time of operation. Through this catheter the bladder should be regularly irrigated not less than twice in twenty-four hours and the acidity of the urine should be maintained. If catheter drainage has been instituted it should be maintained until the bladder wound is firmly healed, a time which can only be ascertained by actual experimentation. Before removal of the catheter it is wise to shut it off for increasing intervals in order to accustom the bladder to the retention of urine. In this way any weakness of the wound will readily be ascertained and constant drainage again instituted. Not until the bladder has become accustomed to retaining six to eight ounces of urine should the catheter be removed. Even at this time it will occasionally happen that the resistance of the vesical sphincter is greater than that of the newly formed scar and the urine will break through, forming a fistula which will heal only after the catheter is replaced. No hesitation should be felt in replacing the catheter if any leakage occurs and generally in a few days' time a firm healing will result. In the average case catheter drainage will have to be maintained for ten days or two weeks. The care of the suprapubic wound other than that which concerns itself with the tube does not essentially differ from drained wounds of any other type. If the bladder has been closed and drainage left down only to the bladder wound this drainage may safely be removed in forty-eight hours. It is wise, however, to see that the skin does not close too rapidly, as slight suppuration in the prevesical space would in this case get an opportunity to extend perhaps seriously.

Confinement to Bed.—The length of time during which patients must be kept in bed after suprapubic lithotomy is influenced by two considerations: First, the presence of drainage whether by the tube or by the catheter, and second, the presence of an abdominal wound. Most patients having a catheter in the urethra will be most comfortable in bed unless there is some particular reason for getting them up, such as exists with elderly patients. Under these circumstances they will ordinarily be confined to bed for ten days or two weeks. The confinement which should be insisted upon on account of the wound itself is less than that following most abdominal operations with a drained wound. If the wound heals kindly without important infection a week will probably be sufficient. On the other hand, any considerable amount of infection obviously increases the liability to weakness of the scar and longer confinement is necessary. In elderly patients confinement to bed may have almost fatal consequences and under these circumstances everything may be sacrificed to the importance of getting them up. In this case, however, we shall do well to warn the patient that a weak scar is not an improbable eventuality. Taking all cases together a confinement to bed of two weeks is about the average.

Complications.—While after litholapaxy the complications centre about the probable infection of the prostate and its appendages so in suprapubic lithotomy the complications centre about wound infection. Since these bladders are generally infected and soiling of the wound in some degree is inevitable, a perfectly asceptic wound is not to be expected. In fact, it is for this reason that complete closure of the wound is rarely if ever desirable. The amount of wound infection will vary from simple redness of the skin to extensive prevesical suppuration. Infection of the prevesical space is not infrequent and pockets of this infection may extend downward on the side well into the pelvis, forming suppurative pericystitis. The presence of such infection can generally be detected by induration about the lower portions of the wound and tenderness along the line of the groin on one or both sides. In the most serious cases the prevesical infection may extend downward into Scarpa's triangle where it will occasionally come to the surface. Where prevesical infection is suspected the lower portion of the wound should be freely opened and ample opportunity for drainage established. Procrastination in this regard is likely to be serious, as the prevesical space is of low resistance and burrowing of pus particularly likely to occur. If attacked promptly it may not importantly prolong convalescence. If treatment is postponed it may prove an exceedingly tedious and occasionally dangerous complication. In former times it was not uncommon to see these wounds crusted with lime salts, a condition which would be very frequent were an ammoniacal condition from the urine allowed to persist. Today we believe that this can be always avoided, but should its possibility have been overlooked and should encrusting of the wound have occurred it should be treated locally with dressings soaked in cultures of the Bulgarian bacillus which will clear up this encrustation with great rapidity. If this is accompanied by appropriate measures within the bladder this incrustation will rapidly disappear and can be prevented from recurrence.

Persistent Urinary Fistula.—If the inlying catheter has been employed a urinary fistula should be of very brief duration and its recurrence is an indication for the replacement of the catheter if it has been removed. If the inlying catheter has not been employed a urinary fistula will persist until such time as the wound in the bladder has closed sufficiently to oppose greater resistance to the exit of urine than does the vesical sphincter. There are some cases, however, in which whether with the inlying catheter or without a persistent urinary fistula occurs. This means obstruction at the vesical outlet which may be due to beginning adenoma of the prostate or to one of the various grades of contracture. In any case its character should be recognized as meaning that this obstruction must be dealt with by operation before closure of the fistula can be expected. If a contracture is found it may be divided from above or from below by the method of Chetwood. In any case the important thing is to recognize that a

persistent suprapubic urinary fistula means obstruction at the vesical outlet and that this obstruction thereby becomes the main factor in the cure.

Pyelonephritis and Septicemia.—Pyelonephritis and the type of septicemia already referred to as occasionally following litholapaxy are occasionally seen as complications. Their frequency, prognoss and management are the same whenever they occur.

Peritonitis.—In a few cases septic peritonitis has followed as a complication after suprapubic cystotomy, practically I believe only in those cases in which the peritoneal cavity was opened accidentally and it was not discovered.

Infectious Arthritis of the Pubic Joint.—This complication has already been referred to in discussing the importance of not incising the periosteum of the pubes. It has occurred in several of our cases and has not been discovered until the patient began to be out of bed. It then appeared that he had considerable difficulty in locomotion, that there was much pain running down the inner side of the thigh and pain in the back referred to the region of the sacro-iliac joint upon one or both sides. For some time we regarded this as an accidental condition of joint strain due to faulty position at the time of operation. A case, however, finally occurred which was so severe as to warrant exploration, and at this time a septic arthritis with looseness of the joint was found. Looking back over our experience we now believe that this has been the cause of a certain amount of disability in a good many patients in whom its presence has not been recognized and are inclined to doubt whether our experience has been entirely peculiar. The only treatment which we have found at all efficient has been the fixing of the pelvic joint by means of an appropriate belt. This has, however, given only partial relief and in at least two cases the disability persisted for six months and then slowly disappeared.

The Probability of Recurrence and Its Prevention.—It is unprofitable to discuss the probability of recurrence for stone in general, as that probability depends largely upon the conditions under which the stone has formed and the nature of the stone itself. The questions can be discussed more intelligently if they are divided into three classes as follows:

1. Vesical calculi having for their nucleus a stone coming down from the kidney.
2. Stone forming primarily in the bladder in the absence of residual urine.
    (*a*) An acid urine.
    (*b*) An alkaline urine.
3. Stones forming primarily in a bladder with residual urine.
    (*a*) In an acid urine.
    (*b*) In an alkaline urine.

1. The probability of the recurrence of a stone having for its nucleus a fragment coming down from the kidney should be small because

the possibility of this occurrence is already known. The possibility of further occurrence of stone in the kidney is of course considerable but its passage to the bladder will rarely occur without clear evidence of the fact. When symptoms of the passage of a renal calculus have occurred it is of essential importance to see that it passes from the bladder promptly or that measures are taken to facilitate its passage or to remove it. Thus following an attack of renal colic if no stone is passed from the bladder an *x*-ray or cystoscopy is clearly indicated. Should a small stone be present in the bladder it will occasionally pass after full dilatation of the urethra with sounds. Should this not occur the stone should promptly be crushed, a procedure which at this stage can generally be satisfactorily carried out at the office under local anesthesia.

2. Primary stone formation in a bladder which has no residual urine is dependent upon certain peculiarities of the urine itself. Unless these peculiarities can be overcome the probability of continued recurrence will of course be large. The formation of stone which occurs in an acid urine can be considerably influenced by modification of this acidity. This is most readily done by diluting the urine markedly by increasing the patient's intake of water. If the urine can be kept really dilute the probability of stone formation is much diminished. Beyond this the actual acidity of the urine can be influenced by the administration of alkali and of these the most efficient is probably the bicarbonate of soda. It is, however, practically out of the question to expect patients to always keep the urine alkaline, neutral or slightly acid, if this cannot be done except by the administration of a drug. It will be found, therefore, that this variety of stone is the most difficult of management. As with the stones which occur in an acid urine, those which form in an alkaline urine will continue to reform unless the reaction of the urine can be entirely and permanently altered. An alkaline reaction of the bladder urine may be dependent upon one or two conditions. It is most commonly due to bladder infection with the urea-splitting organism with the production of ammonia. This will result in the formation of phosphatic stone and their recurrence can be profoundly influenced and probably prevented by the alteration of the reaction of the urine. This alkaline decomposition due to infection may occur either in the bladder or in the kidney. If the infection is of the bladder I believe it can generally be controlled by the use of the Bacillus bulgaricus as previously described. Upon the rather scant evidence now at hand it is clear that the reaction can be greatly changed and kept acid for a reasonable length of time. During this time stone recurrence has not been observed in our cases. The ultimate question will depend upon the possibility of making this condition permanent. Observations up to the present time incline me to the view that by this method the infecting organism can be stamped out and that a condition probably permanent can be brought about in which if it is not possible to completely cure the bladder infection the infecting

organism will be the colon bacillus and not the urea-splitting group of organisms. In a certain number of cases it will soon be discovered that the alkaline decomposition of the urine takes place not in the bladder but in one or both kidneys. This presupposes a condition of moderate pyonephrosis and we have no reason to assert that the introduction of the Bulgarian bacillus to the bladder will have any effect whatever upon this process. I am not aware that there is any evidence bearing upon the question of whether the Bulgarian bacillus can be introduced with safety into the kidney and whether if so introduced it will produce the desired effect upon the urine. As the case stands at present the alteration of this reaction must depend upon the improvement of the condition of the kidney by some operation, probably nephrotomy. The feasibility of such an operation need not be discussed here, as it comes more appropriately under the discussion of infections of the kidney. The other type of persistently alkaline urine is due to conditions of secretion or excretion and occurs in the kidney itself, as in the condition of persistent phosphaturia which, though uncommon, is by no means very rare. The remedy of this condition can be brought about only by alterations in diet and at the present time no satisfactory method has been devised. As in the case of formation of calculi in acid urine, dilution of the urine is valuable. In our experience no drug has favorably affected it.

3. Primary stone formation in bladders having residual urine.

There are here two factors to be dealt with, first the residual urine and second the condition leading to the residual. It may safely be said that the probability of the recurrence of stone in a bladder containing residual urine is very large. The first step in the management of such a situation consists in the searching out of the cause of the residual. Where this is due to changes in the prostate other than malignant disease, to diverticulum of the bladder, to stricture of the urethra or to sagging of the anterior vaginal wall in women the appropriate operation of prostatectomy, prostatotomy, urethrotomy, diverticulectomy or repair of the perineum is indicated. If the residual be due to some condition which cannot be favorably influenced by operation, such as malignant disease of the prostate or faulty innervation of the bladder, the treatment is profoundly handicapped. It should be clearly recognized, however, that the removal of the obstruction even if it entirely does away with the residual urine does not in itself put a stop to the conditions which produce stone formation. The residual urine was only a factor which increased the readiness with which stone formed but did not fundamentally cause it. Therefore, after the removal of the obstruction the same treatment which was laid down above in the absence of residual is still clearly indicated. If the residual urine cannot be overcome or if in spite of operation some slight residual persists, as is not rarely the case even after prostatectomy, it is of essential importance that this residual be regularly removed by the use of the catheter. This combined with regular washing of

the bladder, maintenance of an acid urine, and increase in the amount of urine secreted by increase of the water intake, will always much diminish the tendency to stone formation and if really conscientiously carried out may entirely prevent it. In all cases where a stone has formed in the bladder the relation of the surgeon to his patient should for a long time in the future be one of armed watchfulness. Close supervision, painstaking care of the urine, occasional cystoscopy and perhaps *x*-rays are the ammunition with which he should be armed. The possibility of recurrence of a stone having for its nucleus a foreign body need not be seriously considered except in the case of the insane. In such persons it can only be prevented by carefully guarding the patient againts the possibility of getting such foreign bodies.

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CHAPTER VI.

FOREIGN BODIES IN THE BLADDER.

By HUGH CABOT, M.D.

Foreign bodies may arrive in the bladder in two general ways:

1. Those introduced through the urethra accidentally or otherwise.

2. Those which reach the bladder by perforation of the overlying tissue, whether by wounds, as in the case of bullets, or in the course of a surgical operation not upon the bladder itself.

1. *Foreign bodies introduced through the urethra* vary from hatpins to straws, from catheters to collar buttons. Almost anything which can be made to pass the urethra has been found to have arrived at the bladder. The greatest variety will, for obvious anatomical reasons, be found in the female. Thus straws, hatpins, quills, safety pins, nails, chewing gum, and catheters, both glass and rubber, have been found and extracted. In the male the variety is somewhat less. Straws, gum in various forms, pieces of wire, and, most commonly, portions of catheters have been found. Similar foreign bodies have been found in the bladders of female children. Thus in a recent case of my own, two hairpins which had been introduced into the bladder at some time unknown were found encrusted with calcareous deposit. One of them had perforated the floor of the bladder and projected into the vaginal wall, the other lay entirely within the bladder. In this case, as commonly in children, there was a notable absence of acute symptoms. The condition gave rise simply to an incontinence which had for many months been mistaken for a simple cystitis (Fig. 50).

2. *Gunshot wounds,* chiefly with single bullets, in the neighborhood of the pelvis have, on many occasions, resulted in the projectile ultimately finding its way into the bladder by the process of abscess formation and perforation. In the days shortly after our Civil War a considerable group of such cases was found, and as this was before the days of the Roentgen rays, and the symptoms were those of vesical calculus, some of them were subjected to litholapaxy, with rather disastrous results. The present war may be expected to give rise to another group of such cases, the diagnosis of which will be readily possible by modern methods.

The other most common source of foreign bodies, not introduced through the urethra, has been *various operations upon the pelvic viscera,* chiefly in women, in which non-absorbent suture material was introduced. Thus in the days when rather heavy silk ligatures were in common use a considerable number of them ultimately found their

way into the bladder, with the formation of secondary calculi. Wire sutures introduced into that portion of the cervix close to the bladder floor have occasionally had a similar result, though in the case of silver wire, most commonly used, calcareous deposits will rarely, if ever, take place. A few cases have been reported in which instruments accidentally left in the abdomen have reached the bladder, though more commonly they perforate the intestine and are passed by rectum. In the majority of cases foreign bodies in the bladder excite inflammation, commonly with urea-splitting organisms, alkaline decomposi-

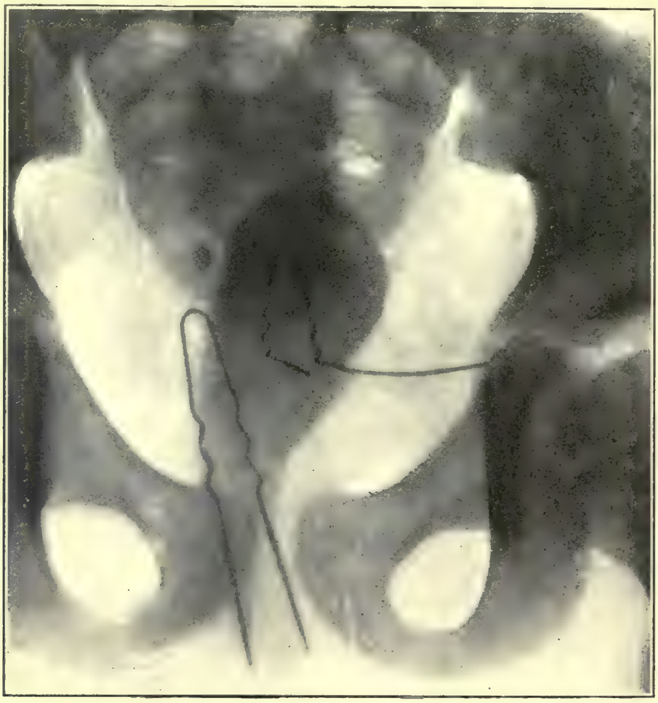

FIG. 50.—Roentgenogram showing two hairpins in the bladder of a female child, one of them (bent) projecting through the vesical vaginal septum.

tion takes place, and phosphatic stones are formed about these foreign bodies as a nucleus. When the stone formation has been such as to completely obscure the foreign body, trouble may arise through failure to recognize the nature of the nucleus, since in these cases an absolute contra-indication to litholapaxy exists except when the foreign body is small and soft, as in the case of silk sutures.

Symptoms.—In the early days, after the introduction of a foreign body, the symptoms are those of sharp bladder irritation readily confusable with various forms of cystitis. Patients are commonly not seen in the early stages, since, as a rule, they trust to a Providence

which will not aid them in the extraction of these bodies. When first seen the symptoms are likely to be those of chronic cystitis with vesical calculus, and it is to be remembered, as above noted, that in children the symptoms of vesical calculus may be highly non-characteristic.

Diagnosis.—The diagnosis is to be made, as in the case of stone in the bladder, with the cystoscope and the Roentgen rays. The latter method is of particular value, as it will, in most cases, show the nature of the nucleus and enable the proper operation to be selected (Fig. 51).

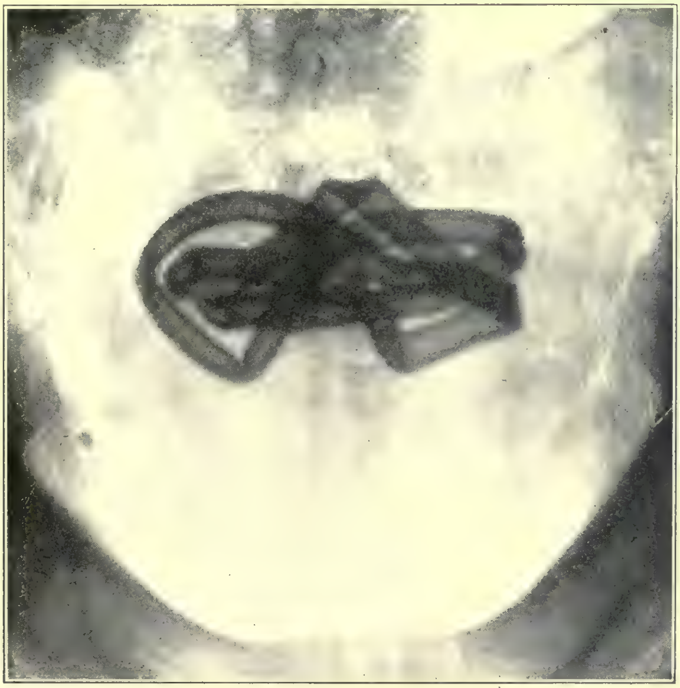

Fig. 51.—This patient had lost a soft-rubber catheter in the bladder some months before he was seen. The symptoms were those of vesical calculus and the nature of the condition was only appreciated after the roentgenogram had been taken.

Treatment.—There are two possible methods of extracting these foreign bodies:

1. Through the urethra.
2. By cutting operations.

1. Foreign bodies of such size that they will pass the urethra readily, and which have not become distorted by calculus formation, may be removed *through the urethra.* Thus, catheters recently lost, filiform bougies, whether those which have been used as a guide and have become separated from the metal tip, or those which have been passed for other purposes, pieces of gum and straws, have been

removed from the male bladder with a lithotrite. The female bladder, owing to the shortness of the urethra, is more accessible, and a variety of bodies, including pins, buttons, quills, catheters, etc., have been successfully removed. In either case the possibility of removal in this way must be determined by a previous cystoscopy. In the male, removal of any foreign body which is not likely to injure the urethra in its passage may be attempted (Fig. 52). I have seen the late A. T. Cabot remove from a male bladder a long straw, the upper two-thirds of which had passed into the right ureter, from which it projected about two inches. His sense of touch was so delicate that, after locating the position of the straw with the cystoscope, he introduced the lithotrite, grasped the straw tenderly by its projecting extremity, and removed it intact. Today such a foreign body would have been more effectively treated by the forceps introduced through the operating cystoscope. This method is valuable for small foreign

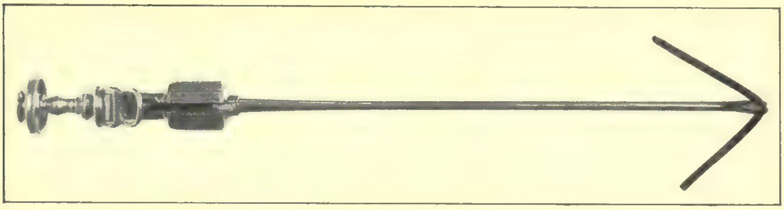

Fig. 52.—This shows a soft-rubber catheter recently lost in the bladder, grasped by a small lithotrite in its central portion and removed. The illustration shows the lithotrite exactly as it was withdrawn.

bodies, such as filiforms, straws, etc., which could be extracted through the lumen of the cystoscope. In the female the same methods may be employed, but the field is considerably enlarged by the use of the straight cystoscopic tube of Kelly, which will enable one to extract any foreign body which will pass through its lumen.

2. *Cutting Operations.*—As a rule any foreign body which cannot be removed through the urethra without danger of trauma should be removed by suprapubic cystotomy. This operation differs in no respect from that applicable to vesical calculi. The employment of drainage through the wound will be governed by the amount and severity of the inflammation. In a few cases vaginal cystotomy may be applicable, but its use should be confined to old women whose general condition is unsatisfactory and in whom the safety of a vaginal cystotomy under local anesthesia counter-balances the discomfort of urinary leakage and the possibility of a vesicovaginal fistula resulting.

CHAPTER VII.

TUMORS OF THE BLADDER.

By JOHN T. GERAGHTY, M.D.

Historical.—Until the last century tumors of the bladder were completely ignored by surgeons; until the end of the fifteenth century no mention of their existence was made by any authors. Finally, near the end of the sixteenth century there appeared the first mention of certain excrescences of the bladder, and many most bizarre theories were put forward as an explanation of them. Lacuna, in 1551, published a work in which he devoted a certain number of pages to a description of tumors of the bladder and laid down certain general rules for their diagnosis and treatment. The diagnosis was principally to be made from the symptoms of painful and difficult urination, and, undoubtedly, many of these so-called tumors of the bladder were confounded with cases of prostatic hypertrophy. For two hundred years following Lacuna very little progress was made in the knowledge of vesical tumors, although many reports were made of tumors found in autopsy subjects. Until the eighteenth century very little was added either to the method of diagnosis or of treatment. Lavages, sounding, and, in cases of complete retention, perforation of the new-growth with an appropriate sound was advised. Many ingenious instruments were devised to give relief to the unfortunate patients in whom the symptoms were extreme. In the beginning of the nineteenth century tumors of the bladder began to be studied from a more scientific stand-point. More careful anatomical and pathological studies were made and, while the diagnosis of these vesical neoplasms still remained as uncertain and obscure as they had in previous centuries, methods of surgical attack developed rather rapidly. Civiale, Leroy d'Etiolles and numerous others began to practice operative procedures on these tumors through the suprapubic region. On exposing the tumors they were handled in various ways; some used instruments resembling clamps, the tumor being twisted off, and by others cautery was employed to destroy the tumor. It is probable that the majority of these earlier tumors operated upon were very extensive because the cystoscope had not yet been developed and the diagnosis was only made in the advanced cases. With the invention of the cystoscope came a rapid development in the early diagnosis of vesical tumors, more careful and complete histological and pathological studies, and gradually the growth of more radical and scientific methods of treat-

ment. In looking over the records of the Johns Hopkins Hospital from 1885 to 1896 it is interesting to note that no case of tumor of the bladder was admitted to the wards in which a diagnosis was made sufficiently early to warrant anything more than suprapubic drainage. It is probable that the early records of other large hospitals will show the same sad series of inoperable tumors of the bladder.

With the development of the cystoscope and the education of the profession to the importance of investigating apparently innocent hematuria a new era arose. A surgical technic for the eradication of this disease was developed, and while the ultimate results have not been as brilliant as in other fields a distinct advance was made.

Various methods were employed by the surgeons in the pedunculated tumors, the clamp and cautery being the measure most frequently practised. When the tumors were broad-based and infiltrating, usually deep cauterization was resorted to. It was soon recognized, however, that even when the tumors were apparently of the benign type and pedunculated, recurrences followed so frequently that many surgeons had almost come to the conclusion that this type of tumor, unless producing symptoms demanding relief, should be let alone and no attempt made to excise it. Gradually the knowledge was acquired that vesical tumors were of peculiar nature, that implantation as the result of trauma to the bladder mucosa could readily occur, and that many of the so-called pedunculated benign tumors were malignant in nature. Many investigators were of the opinion that all papillomata, even those apparently histologically benign, were really cancerous in nature. With the diffusion of this knowledge more radical methods were adopted, and within comparatively recent years, resection of the portion of the bladder wall, from which the tumor arose, became the operation of choice. This method of attack was advocated boldly for all tumors regardless of whether they were papilloma or infiltrating carcinoma. As radical and as extensive as these measures were, the results were far from gratifying, and recurrences seemed almost as frequent as from the simple methods of earlier years. While more and more radical surgical procedures were developing and being advocated the endovesical method of attacking these tumors was being perfected. We find Nitze, in 1896, reporting a large series of cases in which he had succeeded in completely eradicating the tumors by his ingenious operating cystoscopes and securing results which were incomparably superior to those obtained by the most radical surgical procedures. The endovesical treatment of bladder tumors, however, did not seem to receive any particular encouragement until Beer, in 1910, reported a method of treating papillomata by means of the high-frequency current. The ease of application of this method and the apparently good primary results encouraged urologists in all parts of the world to try this form of treatment. The last five years have now accumulated sufficient evidence to show that for certain types of tumor, namely, the papillomata, it is the ideal form of treatment, and

that results are obtained by this method which cannot be duplicated by even the most radical surgery. More recently the addition of radium to our therapeutic armamentarium promises to aid, in a not inconsiderable degree, the modern methods of attacking these tumors.

Etiology.—The explanation of the cause of bladder tumors will probably not be unfolded until we have more precise and accurate knowledge concerning the formation of tumors of any kind in other portions of the body. Speculations and theories of all kinds have been put forward, but they have not served in any way to bring us nearer the true explanation of their development. Repeated irritation, mechanical, chemical, or of parasitic nature, has been assigned as the predisposing factor by innumerable authors. In support of this theory is frequently quoted the well-known fact of the great frequency of vesical tumors in the anilin dye workers, it being supposed that the excretion of the anilin dye in the urine produces a chemical irritation which eventually leads to tumor formation. Irritation of cystitis and calculi have been considered by some as predisposing factors, without any plausible reason whatsoever. The most superficial study of tumors of the bladder will reveal the fact that neither one of these complications is present in over a small percentage of tumor cases in the early stages. Speculations at the present time regarding the etiology of epithelial tumors or those of connective tissue or muscle origin is entirely futile in the present state of our knowledge.

Pathology.—Tumors of epithelial origin form over 90 per cent. of all tumors of the bladder, and, hence, for the surgeon, are the tumors of greatest importance. The multiplicity of terms applied to the epithelial tumors by various investigators and the different classifications proposed have resulted in much confusion. Guyon, taking as a basis for classification the mode of implantation on the bladder wall, has divided epithelial tumors into pedunculated, implanted, and infiltrating. The pedunculated tumors are those classed by the most recent writers under the name papilloma. The implanted tumor, according to his classification, is one springing from the mucous membrane and projecting into the vesical cavity; it is non-pedunculated and presents no advanced infiltration of the bladder wall. By infiltrating tumors he refers to a peculiar class of neoplasm which involves extensively and deeply the bladder wall, but projects only slightly into the bladder cavity.

Much of the confusion concerning the classification has arisen from the various terms applied to the group of tumors now usually classed under the head of papillomata, and the name fungous, fimbriated, fibropapilloma, villous tumor, etc., have been used by different investigators in referring to the same type of growth. Küster has proposed a classification, based on the histogenesis of tumors, dividing them into three groups according to whether their principal elements are derived from epithelial, connective tissue, or muscular elements of the bladder. Albarran has adopted the same general classification,

but adds another group under the term "heterotopic" to include rare forms of tumors; such as rhabdomyoma, chondroma, etc., which are not derived from any normal elements of the bladder wall.

Classification.—The classification of the tumors of epithelial, connective tissue, and muscular origin proposed by Küster and Albarran is almost universally accepted. The following is the classification which has been adopted, and seems to us the most satisfactory:

- Tumors of epithelial origin
  - Papilloma
    - Benign.
    - Malignant.
  - Adenoma.
  - Cysts.
  - Carcinoma
    - Papillary.
    - Scirrhous.
    - Squamous.
    - Adeno.
- Tumors of connective-tissue origin
  - Sarcoma.
  - Myxoma.
  - Fibromyoma.
  - Fibroma.
  - Angioma.
- Tumors of muscular origin
  - Myoma.
- Heterotopic
  - Rhabdomyoma.
  - Hydatid cysts.
  - Dermoid cysts.
  - Chondroma.
  - Cholesteatoma.

TUMORS OF EPITHELIAL ORIGIN.

Papilloma.—Papilloma is a name which common usage has popularized in medical literature, and it is used to denote a group of tumors having certain gross characteristics. The term is synonymous with the villous polyp or fibropapilloma of Virchow, the fimbriated papilloma of Thompson, the zöttenpolyp of Küster, while Rokitanski includes them under the general term of villous cancer. The term papilloma has come to imply a pedunculated, papillary, or villous tumor springing from the mucous membrane of the bladder and being essentially composed of a branching connective-tissue framework, lined by epithelium in several or many layers, but in which infiltration of the bladder wall is absent. The term papilloma, as it will be used, refers simply to the group of tumors having the above-described characteristics, and denotes nothing concerning its benign or malignant nature.

Frequency.—Modern statistics prove conclusively that the papilloma is by far the most frequent tumor of the bladder, and if it is further considered that practically all papillary carcinomata, represent the advanced malignant degeneration of tumors, which in the early stages were papillomata, some idea of the preponderance of this type of vesical neoplasm can be obtained. In a series of 180 cases from the Johns Hopkins Hospital, 79 were diagnosed papillomata. Buerger in an examination of 113 vesical tumors found 55 to be papillomata and 45

to be papillary carcinoma. Von Frisch in 300 tumors of the bladder found 201 to be papillomata. Albarran found 28 papillomata in a series of 98 tumors of the bladder studied histologically.

Location.—In our series in 70 cases in which the position was indicated the tumors were found as follows:

Anterior bladder wall	7
Base of bladder	8
Trigone and vesical orifice	9
Right lateral wall	4
Left lateral wall	8
Near right ureteral orifice	18
Near left ureteral orifice	16

Fenwick reports that 43 per cent. are found close to the ureteral orifices, and practically all authorities agree that the bladder wall near the ureteral orifices and the posterior wall immediately back of the trigone are the portions of the bladder most frequently involved. While the tumors seem to display a predilection for the above portions of the bladder they may be found, however, on practically any surface. The frequency of tumor formation in the region near the trigone and neighboring portions of the bladder wall has no suitable explanation.

Sex and Age.—*Sex.*—Papilloma appears to be much more frequent in men than in women. All modern authors are in accord on this point. Clado in 47 observations found only 15 in women. In our series only 5 were in women. The small proportion of women in our series is to be explained by the fact that the material was largely drawn from the male clinic.

Age.—In 73 patients with papillomata the ages were as follows:

10 to 20 years	1
21 to 30 "	5
31 to 40 "	13
41 to 50 "	23
51 to 60 "	18
61 to 70 "	11
71 to 80 "	2

In 89 cases of carcinomata the ages were as follows:

10 to 20 years	0
21 to 30 "	0
31 to 40 "	3
41 to 50 "	10
51 to 60 "	33
61 to 70 "	28
71 to 80 "	15

Tumors of the bladder are undoubtedly quite rare below the age of thirty years. Küster reports them most frequently between the ages of thirty and sixty years, while Stein considers they are more frequent between the ages of thirty-two and fifty years. The youngest in our series was a boy, aged fifteen years. In 22 patients below the age of

forty years, in 19 the tumors were papillomata and in 3 infiltrating carcinoma. In our material 78 per cent. of the papillomata were found between thirty and sixty years of age, while 68.5 per cent. of the carcinomata occurred in patients between fifty and seventy years.

Number.—Papillomata occur as multiple tumors more frequently than any other neoplasm. In our series of papillomata 66 per cent. were single and 34 per cent. multiple. The number may vary from 1 or 2 up to as many as 100. In some instances a papilloma is found which practically fills the entire vesical cavity; at other times several smaller-sized tumors may be present or associated with innumerable papillomatous growths scattered over all portions of the bladder wall. In two cases in our series the papillomata were so numerous that it was difficult to find an area in which the vesical mucosa was normal. Albarran reports such a case and Thompson has also described remarkable examples.

Gross Appearance.—The surface appearance of these tumors varies considerably, and there is no definite characteristic which will differentiate the malignant from the benign. Great variations in the relative amounts of epithelium and connective tissue occur in the various tumors, together with marked difference in their manner of implantation on the bladder wall. Notwithstanding this, two general types of papilloma can be recognized.

In one, which is commonly known as the villous type, the filaments spring directly from the mucosa, as described by Davis, "like a tuft of grass from a circumscribed base" (Fig. 53). The filaments are extremely delicate and the connective-tissue framework is very slender. When submerged in water the extreme fineness of the filaments can be appreciated, but on removal the villi collapse, resulting in a soft, sponge-like mass. The villi are of variable length. In some cases they are only a few millimeters in length and in others they may attain a development of many centimeters. These tumors have no definite pedicle. Their number and size vary greatly. The different filaments are usually united at the base to form groups of varying size, and sometimes an extensive portion of the bladder may be involved by these more or less separate tumor groups; so much so that Thompson and Küster have applied the name "villous disease." Albarran has described a condition in which he applied the name "villous disease," in which numerous fine villi are found springing from a portion or even the entire mucous membrane. He reports a case upon which he operated and cured by extensive curettage. Küster reports a similar case in a man, aged twenty-four years, the vesical mucosa, the trigone, the anterior wall, and the apex were covered by vast numbers of villous projections. He was also cured by curettage. This condition is probably inflammatory, and limited areas are not infrequently seen in cystitis. The condition must be distinguished from that of true tumor formation.

In the second form there is present more or less well-developed

pedicle from which the villi spring (Fig. 54). The papillary projections are shorter, more compact, and, when seen through the cystoscope, often grossly resemble the surface appearance of a raspberry. Sometimes they have a more or less lobulated appearance. The pedicle varies in length, although it is usually quite short. Fenwick describes a case, however, with a pedicle so long that it allowed considerable excursion of the tumor mass in the bladder cavity. The consistency of the pedicle varies somewhat with the amount of connective

FIG. 53.—Benign papilloma type which is readily destroyed by fulguration.

tissue which it contains, but it is always firmer than the periphery of the tumor. The mucous membrane to which it is attached is freely movable over the underlying muscularis, which is an important point in differentiating it from papillary carcinoma. On median section through the body of the tumor and pedicle the gross internal structure resembles roughly that of a tree with its trunk and multiple branches. The connective-tissue framework is heaviest toward the base, gradually thinning out until it becomes almost imperceptible near the surface. The size of the pedicle bears no relation to the size of the tumor.

In some the pedicle is comparatively thick and short and numerous, more or less distinct, and separable villi project from the knob-like end. The consistence of papillomata is usually soft and jelly-like. They are extremely friable, and when a portion is seized with a clamp, readily tear asunder.

In most instances it is impossible from the gross appearance to determine the character of the growth, so closely in general appearance do the benign and malignant papillomata resemble each other.

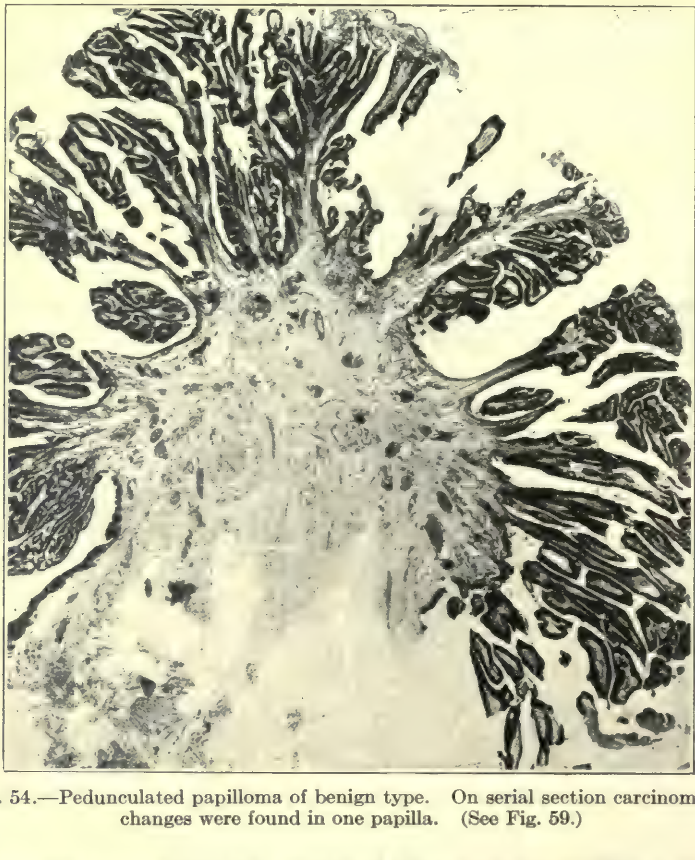

FIG. 54.—Pedunculated papilloma of benign type. On serial section carcinomatous changes were found in one papilla. (See Fig. 59.)

The mucosa from which the pedicle of the malignant papilloma springs may be freely movable upon the underlying structures, and there may be nothing in the appearance to reveal its malignant character. In the vast majority of cases the differentiation between the benign and malignant papilloma can be made only by careful microscopic study, and it sometimes necessitates the examination of sections from various portions of the tumor. Indeed, occasionally even careful microscopic study fails to reveal the true nature of the growth. In many malignant papillomata the cancerous nature is at once apparent both in

general architecture as well as in the epithelial infiltration of the connective-tissue framework, but at other times the histological picture may resemble on superficial examination a benign papilloma. In the benign papilloma the connective-tissue axis is lined by an epithelium which has a palisade arrangement at the base, and above this many layers of oval, long-tailed cells which are uniform in size, shape, and staining characteristics. Toward the surface the cells become flattened and the most superficial are similar to the epithelium of the normal bladder mucosa. In the malignant papilloma the

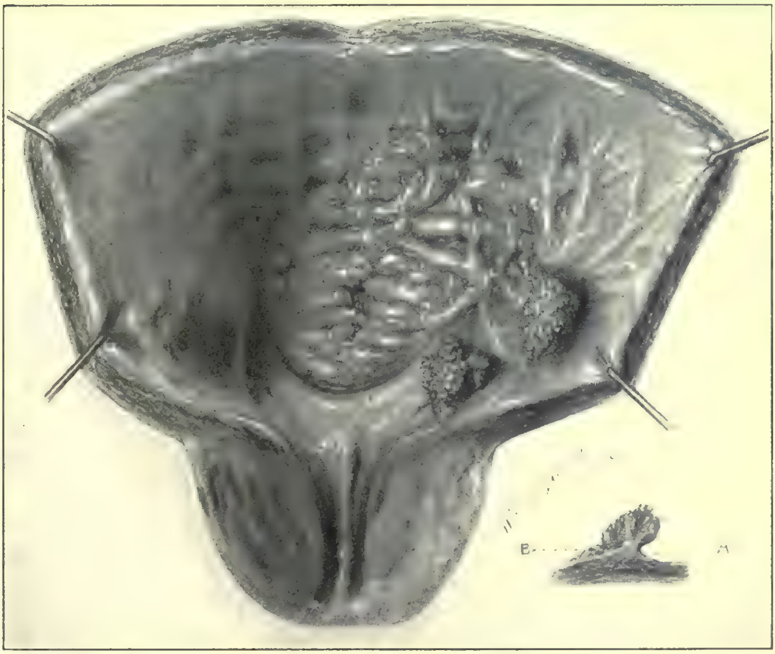

FIG. 55.—Bladder contains two malignant papillomata. *A*, cross-section of one of these tumors. Note that it is pedunculated but that the papillary tumor mass is spreading on the mucous membrane of the adjacent bladder wall at *B*. It has not yet infiltrated below the mucosa.

arrangement of the epithelium is changed and instead of being in regular uniform layers it is disordered. The individual cells are irregular in size and shape and take the stain with varying degrees of intensity. These variations from normal are even more evident in the nuclei. At times, owing to the lawless growth of the epithelium, the papillæ fuse, so that the regular papillary arrangement is destroyed. Not infrequently, in the same field, papillæ may be seen undergoing various degrees of alteration. In one portion the epithelium may have all the characteristics of the benign papilloma, but close by may be papillæ in which epithelial changes characteristic of the malignant

papilloma are very evident. Sometimes the malignant picture is best seen in sections from the surface, while, again, sections from the

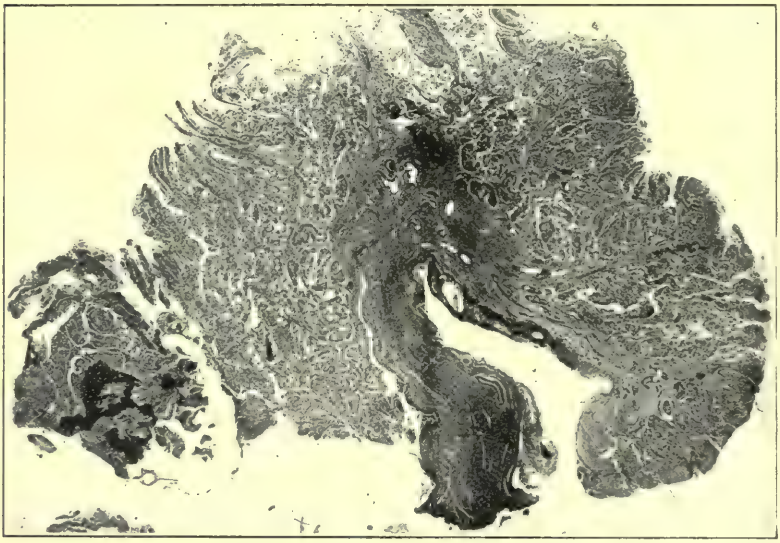

FIG. 56.—Malignant papilloma, pedunculated. Note extensive carcinomatous changes in periphery and body of tumor, with fusion of papillæ.

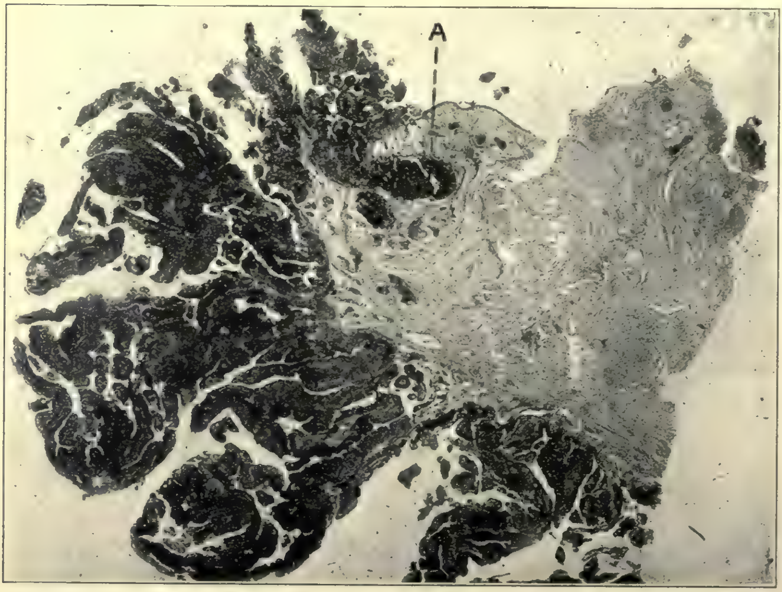

FIG. 57.—Papillary carcinoma; note beginning fusion of papillæ and invasion of base at *A*. This tumor probably was originally similar to Fig. 56.

middle of the tumor or portions near the base may show the most marked evidence of malignancy. The old view that the nature of the tumor is to be decided upon after examination of its base is distinctly erroneous. It has now been proved repeatedly that the base of a papilloma may show no signs of infiltration, and yet the tumor may be distinctly malignant in its body and periphery (Fig. 54). When infiltration of the base does occur the tumor ceases to be a true papilloma and becomes rapidly sessile—a distinct papillary carcinoma (Figs. 56, 57, 58). The diagnosis of a malignant papilloma is at times very simple, as the histological changes are characteristic of typical carcinoma,

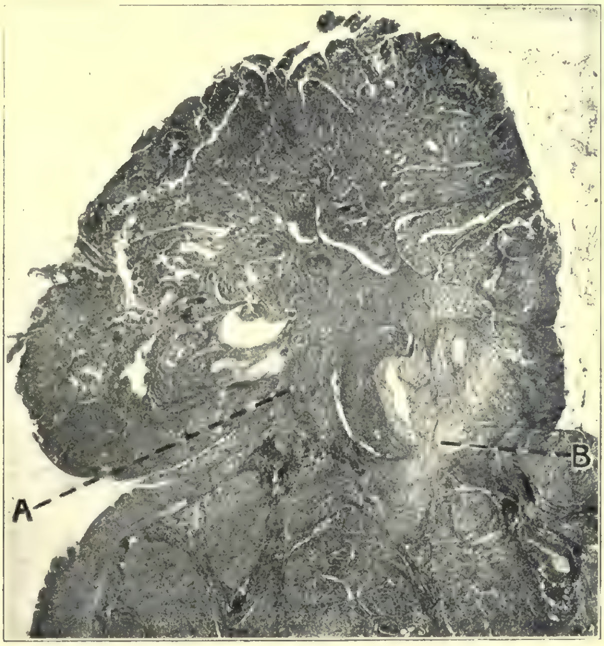

Fig. 58.—Papillary carcinoma. Changes more advanced than in Fig. 57. Tumor originally a papilloma. *A*, original pedicle; *B*, overhanging edge of tumor which has invaded the bladder wall below, so that the tumor is apparently broad-based.

while at other times the histological picture, as a whole, resembles so closely the benign tumor that only a careful study of numerous sections by an experienced pathologist will reveal its true nature. From the tumor shown in Fig. 54, serial sections were made, and near the tip of one papilla a definite cancer area was discovered (Fig. 59). The remainder of the tumor was typically benign. The tumor had been removed by a radical resection and the patient has remained well during the five years since operation. Probably in no other tumor have so many mistakes been made by the pathologists. It should be emphasized that in papillomata evidence of epithelial infiltration of

the connective-tissue stalks is not necessary for the diagnosis of malignancy, and that every papilloma that shows the slightest change either in arrangement, shape, size, or staining properties of the epithelium should be looked upon as malignant. It must be admitted, however, that there is no histological picture which can be considered as always absolutely characteristic of either benignancy or malignancy.

Relative Frequency of Benign and Malignant Papilloma.—There has been an interesting change of opinion regarding the relative frequency of benign and malignant papillomata. Most of the early investigators considered that the benign papilloma was by far the more frequent. Rokitanski, however, differed radically in his views and classed practically all the papillomata as villous cancer. In recent years there

FIG. 59.—*A*, area of carcinoma in a papilla. The remainder of the tumor histologically benign.

has been a gradual trend toward the more radical views of Rokitanski, and most investigators at the present day are of the opinion that the vast majority of papillomata are to be considered as malignant tumors. In our series 68 per cent. were diagnosed histologically as malignant. Albarran in 28 papillomata found 13 benign and 15 malignant. Von Frisch in a series of 201 papillomata, upon careful histological study, classed 107 as malignant. The trend of opinion today is unquestionably to consider as malignant the majority of papillomata, and that ultimately all benign papillomata tend to become malignant. The evidence is rather strong in favor of the view that benign papillomata may, and frequently do, undergo malignant degeneration. Many instances of papillomata present for ten, fifteen, and twenty years have been reported, and at the time of operation found to be malignant,

with subsequent death from recurrences and metastases. It seems fairly reasonable to suppose that these tumors could not have been malignant from the beginning, as the long duration of life would be very unusual. The following case illustrates the long interval which may elapse between the appearance of a papilloma and its final transformation into carcinoma: A male patient, aged forty-eight years, gave a history of hematuria appearing twenty years previously. Five years later a papillary tumor was removed suprapubically. The hematuria recurred in two years and continued intermittently until his admission to the hospital. Examination revealed multiple papillary carcinomata involving the entire bladder. Death from carcinoma occurred one year later.

On the other hand, instances are met with occasionally in which a papilloma histologically malignant recurs repeatedly over a period of years, each recurrence being a pedunculated papilloma with malignant changes. The following case is an instance of multiple recurrences of malignant papillomata extending over a period of twelve years, invasion of the bladder wall not occurring, and the patient never developing clinical signs of cancer: A male patient, aged forty-five years, gave a history of hematuria of one year's duration. Examination showed a papillary tumor near the right ureteral orifice. This was removed by suprapubic excision, and on microscopic examination was found to be a very definite malignant papilloma. Three years later hematuria recurred and three papillary tumors were discovered. These were again removed suprapubically, all three tumors being histologically malignant. The patient was seen again six years later, examination at this time revealing a large number of papillary tumors on various portions of the bladder wall. These were again removed suprapubically by means of clamp and cautery and none of the tumors was found to have invaded the bladder wall. Histological examination showed the tumors to be definitely malignant. The patient was seen one year later and, on cystoscopic examination, many recurrent tumors were found. The general condition of the patient was excellent except for a myocarditis. There had been no loss of weight nor was there present any clinical evidence of cancer. He died one year later from his cardiac condition.

Again, one may find in a papilloma which shows largely a benign picture, papillæ which have undoubted malignant changes and even typical cancer areas (Fig. 54). Irritation and trauma seem to have a marked tendency to accelerate this malignant degeneration. Not uncommonly where multiple tumors are present, some of the tumors may have a benign type of structure while others will be mostly malignant. When the tumors are multiple it usually indicates malignancy.

Recurrences.—Papillomata, both benign and malignant, have characteristics peculiar to themselves. In the first place they act very much like infections, in that they implant themselves readily in the

bladder mucous membrane when trauma is done. The experience of removing a single tumor, to be followed shortly by multiple recur-

FIG. 60.—Longitudinal section of a typical benign papilloma.

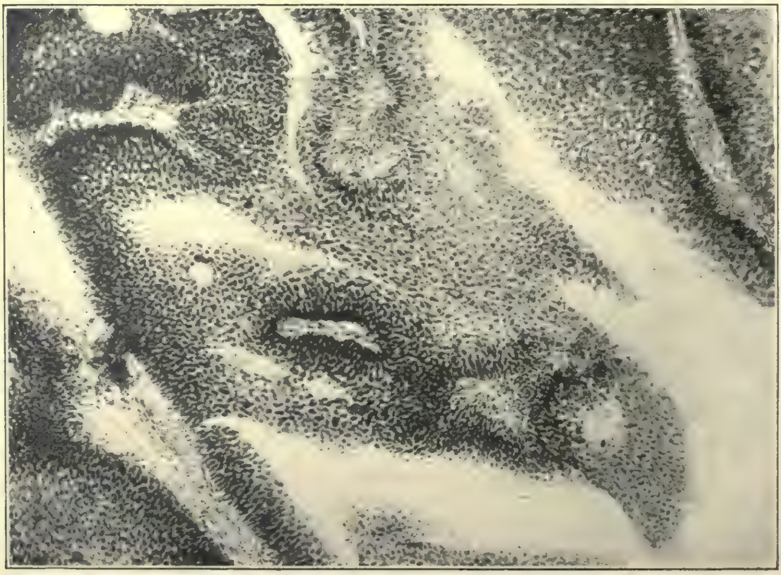

FIG. 61.—Cross-section of a typical benign papilloma.

rences in different portions of the bladder, is one not unfamiliar to most surgeons. They also have a marked tendency to implant themselves along the suprapubic tract, and in our series of operated cases, recurrences were seen in this region in five. This property of implantation was not sufficiently recognized by the earlier surgeons, and should call for the strictest care when operative procedures are carried out, to prevent portions of the tumor from being broken off and implanted on a traumatized bladder wall. The original tumor and

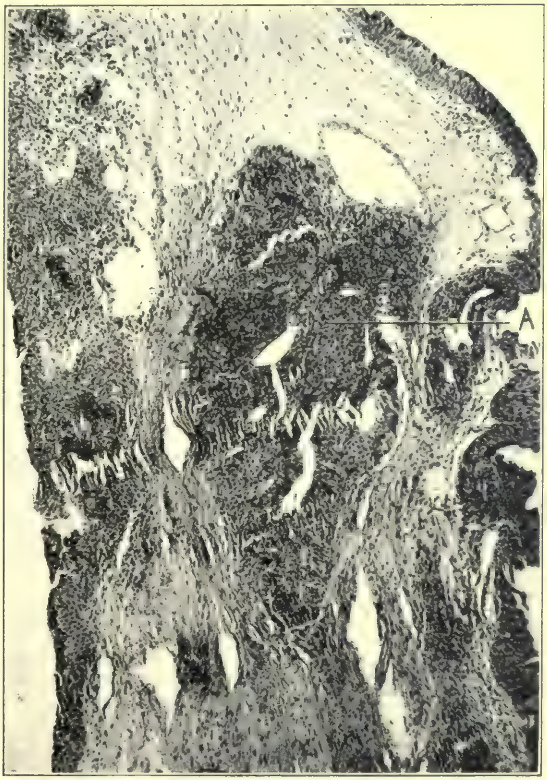

Fig. 62.—Cancer area in the centre of an otherwise benign papilla. Definite malignancy found in other portions of tumor.

possibly one or two recurrences may be benign, but eventually the recurrences are malignant. Conversely, rare instances have been reported in which a histologically malignant tumor has been removed, to be followed later by a recurrence which was histologically benign. Two explanations are possible: either the factor producing the original tumor was still potent, assuming that it was originally benign, or tissue from benign papillæ was implanted at another point of the mucosa, resulting in a benign type of tumor. It is reasonable to assume that

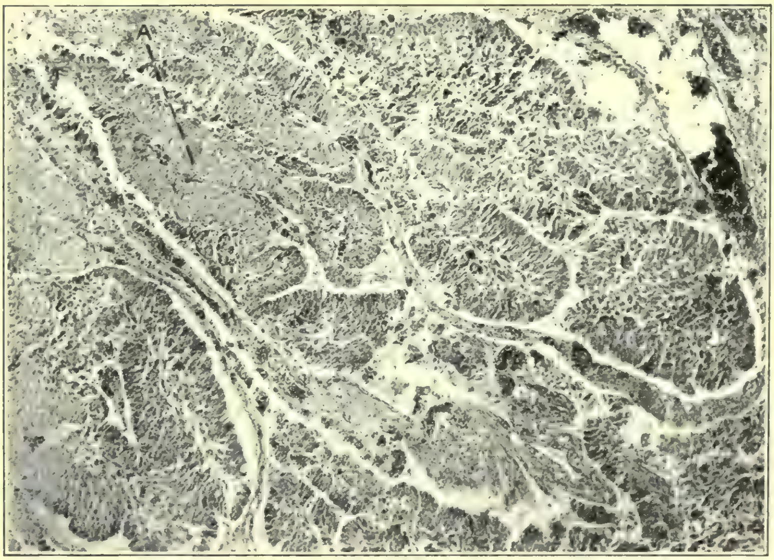

Fig. 63.—Benign papilloma undergoing malignancy. *A*, changes in staining properties of epithelial cells.

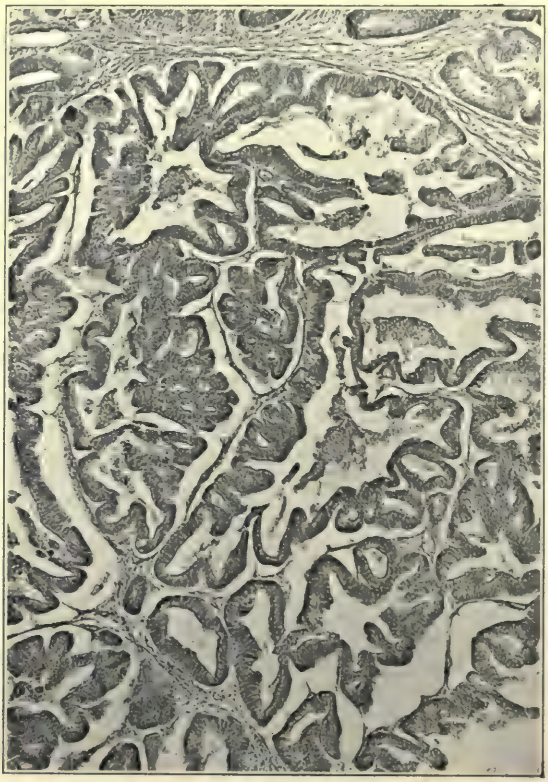

Fig. 64.—An unusual form of malignant papilloma. Microscopic section.

had tissue from a malignant papilla been implanted a malignant tumor would have resulted. The recurrence of these tumors is usually not at the site of the former tumor but in other portions of the bladder, so that failure to cure in most cases has not been from insufficient removal of the original tumor. While most of the recurrences are probably implantations, all of them, however, cannot be so considered. Occasionally a case is seen in which the bladder has remained free of disease for many years, and then a second tumor arises in a portion of the bladder different from the site of the original tumor.

Adenoma.—Adenoma of the bladder is a rather rare tumor, and it arises from the gland elements which are commonly present in various parts of the bladder wall, but particularly in the region of the trigone. It is more common in men than in women, and the majority of cases have been reported in individuals about middle life, although several instances of adenoma in early life have been reported. In the 2 cases in our series both were men aged thirty-two and twenty-one years respectively. The tumor in each instance was similar, both grossly and histologically, and sprang from the trigone near the vesical orifice. The surface was lobular but covered with smooth mucous membrane. In one of these cases the tumor was under observation six years and grew very slowly during this time.

Cysts.—Cysts occur as two distinct types, viz.: small and large. The small cysts are the result of epithelial proliferation with subsequent colloid-like degeneration of the central portion of the epithelial mass. These cysts are usually very small, and may be scattered extensively over the bladder surface. They are of comparatively small practical importance. The term cystitis cystica is applied to this condition. The large cysts (there have been four in our series) arise from the glands of the mucous membrane, and when they are present near the vesical orifice may produce difficult urination or even complete retention, as happened in two of our cases. These cysts are usually single but may be multiple (Fig. 65). Microscopic examination shows the wall of the cyst, which is thin, to be lined both externally and internally with epithelium, the inner layer being the epithelium of the gland and the outer layer the epithelium of the mucous membrane of the bladder. Between the two epithelial layers there is a thin framework of connective tissue.

Carcinoma.—**Papillary Carcinoma.**—This term we have applied to all the villous or papillary tumors in which infiltration of the bladder wall or pedicle has occurred. In most instances the tumor has been originally a papilloma, and frequently the papilloma character of the surface of the tumor is well preserved. Occasionally this infiltration of the base may be fairly extensive even when the histologically malignant changes in the peripheral portion of the tumor are comparatively slight. Buerger has reported a case in which nests of cancer cells were found in the bladder wall below a papilloma apparently typically benign both macroscopically and histologically. This, however, is

FIG. 65.—Multiple cysts of posterior bladder wall. *A*, diverticulum.

FIG. 66.—An unusual form of papillary carcinoma, non-pedunculated, involving only slightly the bladder wall.

rare. The number and size may be as variable as in the papilloma itself. Sometimes the tumor is single, with deep infiltration of the bladder wall; sometimes the tumors are multiple, some showing marked infiltration and others only slight, retaining moderately well their original pedunculated character. At times the bladder may be almost completely filled with these papillary carcinomata. On cross-section of one of these tumors the portion projecting into the bladder resembles grossly the general structure of a papilloma, but the growth of the cancer into the bladder wall can be seen distinctly

FIG. 67.—Multiple carcinomata.

with the naked eye. Microscopically the surface of the tumor frequently resembles the malignant papilloma, while sections from the base show the typical picture of infiltrating cancer growing lawlessly and wildly in the submucosa, and in between the muscle bundles. The appearance of the tumors varies considerably. Sometimes a large portion of the bladder wall is completely covered, the surface of the tumor having a shaggy, irregular appearance. The tumor, as a rule, is soft and friable, and the French have applied the name of encephaloid to this class of tumor because of this peculiar characteristic. Sometimes the growth projects markedly into the bladder and

forms a large intravesical mass; at other times it is rather flat and covers a considerable portion of the bladder wall. Frequently on the mucous membrane near the margin of the tumor can be seen little nodules which represent an infiltration of the tumor beneath the mucosa. When infection occurs the vegetations are frequently covered with mucopurulent material, and occasionally necrotic areas are seen on the surface of the tumor.

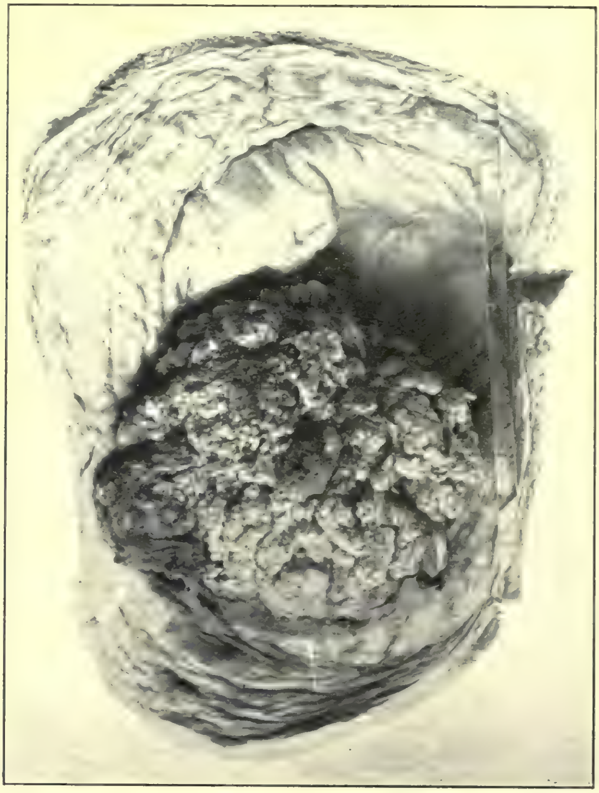

FIG. 68.—Extensive papillary carcinoma.

Scirrhous Carcinoma.—Scirrhous carcinoma is considerably less frequent than papillary carcinoma. Its point of location in the bladder is, however, not dissimilar from that of the papillary carcinoma. The tumors are rarely as extensive and differ considerably in their macroscopic appearance. The surface of the tumor is more or less smooth, inasmuch as it is not covered by small vegetations or papillæ. The base of the tumor is usually as broad, if not broader, than the surface. Frequently the surface of the tumor presents more or less of a lobulated, mammillated appearance, with cracks and fissures running in an irregular manner (Fig. 69). On palpation the tumor is

extremely hard and the infiltration of the bladder wall is extensive. These tumors are more apt to be single, and it is rather uncommon to find multiple scirrhous carcinomata. Cystoscopically they can be readily differentiated from the papillary type of cancer because of these surface characteristics. Not infrequently hematuria occurs in this type of tumor, and the blood can be seen oozing from fissures or slight ulcerated areas on its surface. On microscopic section the tumor is seen to owe its firm consistency to a considerable amount of connective tissue with cancer cells growing lawlessly in columns and irregular masses infiltrating in all directions.

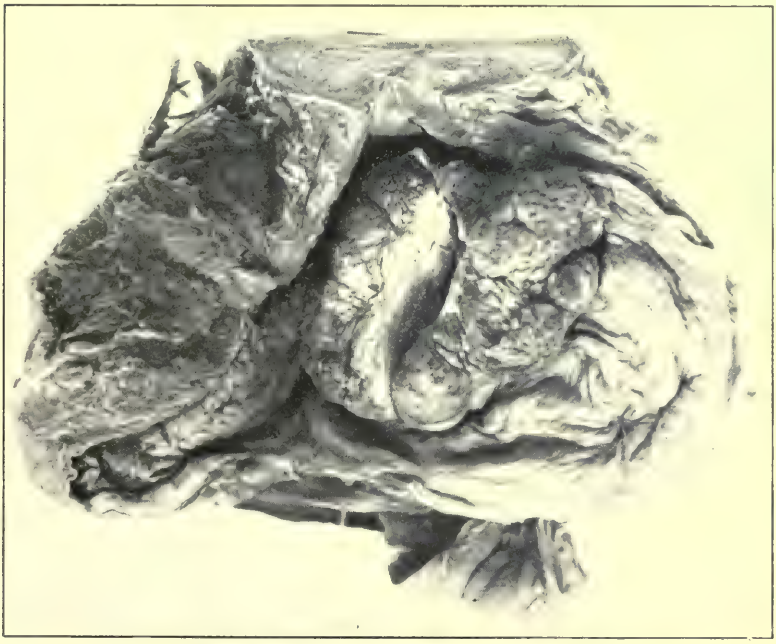

FIG. 69.—Large scirrhous carcinoma.

A peculiar form of cancer, which has been referred to as an infiltrating type, deserves separate consideration. We have had three such tumors in our series. In this variety no evident tumor is present on the surface of the bladder. The vesical walls are hypertrophied throughout to a great extent. The thickening of the bladder wall varies considerably, according to the degree of infiltration, and it may be as much as 4 cm. in thickness. When one sees the surface of the bladder which is the seat of an infiltrating type of carcinoma it is not always possible at first sight to differentiate it from the lesions which are frequently found in cystitis. The bladder is usually markedly contracted. In 2 of our cases the whole bladder wall was destroyed by this infiltrating carcinoma, but in neither instance was there any

projection of the tumor into the bladder cavity. The inner surface of the bladder is irregular, small nodules are visible here and there, and sometimes ulcerations which simulate very closely the lesions seen in severe ulcerative cystitis. The walls may be almost cartilaginous in their consistency. Cystoscopic examination is usually very unsatisfactory on account of the irritability and contraction of the bladder, and the diagnosis may be difficult. The microscopic picture shows the usual infiltrating type of cancer, the walls being completely replaced by cancer infiltration.

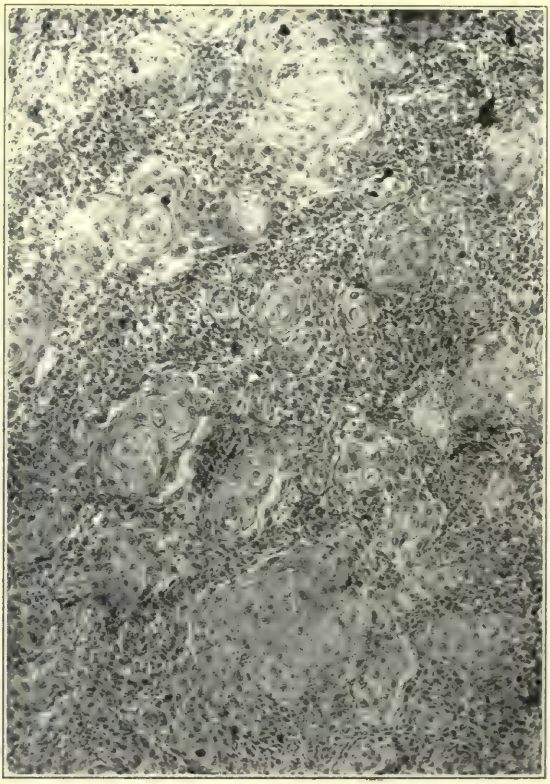

Fig. 70.—Microscopic section of squamous-cell carcinoma.

Squamous Carcinoma.—Squamous carcinoma is quite rare, having occurred only once in our series. It usually appears as a flat ulcerated growth which involves rapidly and extensively the bladder wall. It projects but slightly into the vesical cavity. Histologically it is principally characterized by the abundant formation of "epithelial pearls," while nests of epithelial cells infiltrate in all directions the underlying bladder wall. Metastases are early and extensive.

Adenocarcinoma.—This occurred in 2 patients, aged fifty-five and sixty-five years respectively. Hematuria was the first symptom in each. In 1 case the tumor was on the left lateral wall and in the other, near the right ureteral orifice. In each case the tumor was a flat, ulcerated growth, with extensive infiltration of the bladder wall. Microscopic examination shows an atypical gland formation with considerable connective-tissue stroma. In areas the gland type is almost lost and a scirrhous, infiltrating form of growth is presented. These tumors are quite malignant and metastasize extensively.

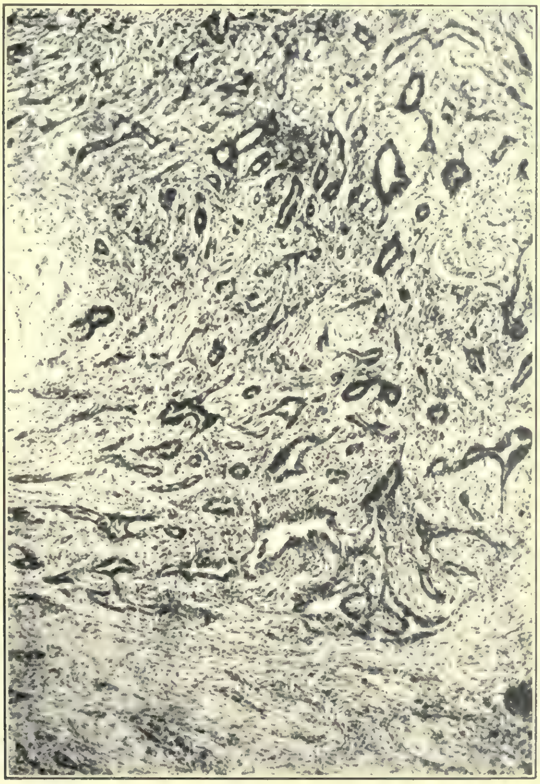

FIG. 71.—Microscopic section of adenocarcinoma.

Clado[1] has described a colloid cancer of the bladder which he obtained from the Guyon collection. He states that it has a predilection for the base of the bladder, but it may occur in other portions. (It is rapidly developing and quickly fills the bladder and invades adjacent structures.) It is usually a single tumor, voluminous, soft, and covered by villous projections. The tumor has an irregular and multilobular appearance. We have seen 1 case of colloid cancer occurring in an extrophied bladder, the patient being forty-eight years of age. The

growth was a diffuse, ulcerated, infiltrating form, involving extensively the abdominal wall. Frequently these tumors ulcerate rapidly and establish communication between the bladder and neighboring organs. Metastases are usually early and extensive.

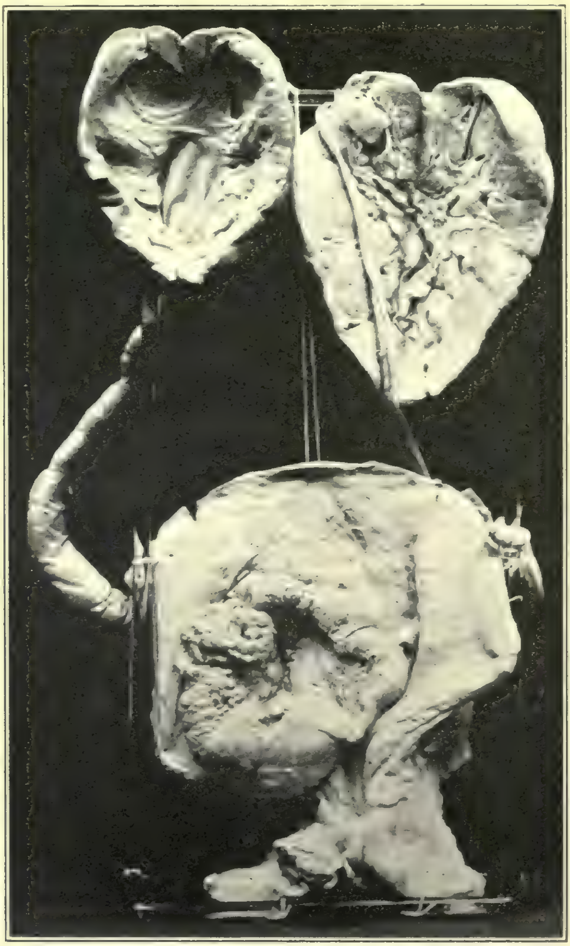

Fig. 72.—Large ulcerated carcinoma obstructing right ureter, producing hydro-ureter and hydronephrosis.

Ulceration in Carcinoma.—Ulceration is not as frequent as one would suppose. It is the result of degeneration of the surface of the tumor from infection or diminished blood supply from interstitial hemorrhage or gangrene. Ulceration or degeneration in the infiltrating form is the most common. In each of our cases of the latter type the tissue showed very marked degeneration and the epithelial elements in many portions of the tumor could be recognized only with

the greatest difficulty. Often the bladder wall seems to have undergone death in large blocks.

Metastases.—It is usually noted that of the bladder tumors, except in comparatively rare instances, remain well confined to the bladder cavity and do not tend to invade the surrounding structures; nevertheless, metastases to distant points are not infrequent. Metastases may occur even when the tumor is small and apparently well localized in the bladder, and Clado reports four observations in which iliac and lumbar glands were extensively involved, although the tumor had not invaded the wall of the bladder. Albarran, in 17 cases, after he had searched carefully for metastases, found them present eleven times. Clado, however, considers that glandular involvement is rather uncommon in the bladder. There are no convincing statistics regarding the frequency of glandular metastases. It is generally admitted that when the tumor is extensive and infiltrates deeply the bladder wall that metastases are practically always present. When, however, the tumor is comparatively small, and only slightly infiltrating, we have no definite statistics as regards the frequency of metastases. That the tumor may be occasionally very extensive, and even deeply infiltrating, without metastases, has come under our personal observation. This patient gave a history of hematuria for several years. Operation showed a tumor, several inches in diameter, projecting markedly into the bladder. The bladder wall was extensively infiltrated, so that one could readily detect the induration on rectal examination, the tumor being on the posterior wall of the bladder. Death occurred some months later from pneumonia, and a careful autopsy failed to show the presence of any metastases in the iliac or lumbar glands, and there was no evidence of secondary growths in any of the organs. On the other hand, metastases may occur in malignant papilloma, in which there is present not the slightest evidence of infiltration of the bladder wall. How frequently this occurs without definite cancerous invasion of the bladder wall itself we have no definite statistics, but it is certainly rare. Metastases to the bones seem to be quite frequent in carcinoma of the bladder, being similar in this respect to carcinoma of the prostate. There seems to be a peculiar tendency of these malignant growths to set up secondary growths in the bones, and metastases to the vertebræ are not infrequent. The liver, lungs and spleen are favorite sites for metastatic processes. In 1 of our cases multiple skin metastases occurred.

Spread by Direct Invasion.—Carcinomata do not display much tendency to invade the neighboring organs, and usually remain confined to the bladder itself, except in rare instances. When, however, the tumors are present around the vesical orifice they not infrequently invade the prostate and may lead to extensive cancerous invasion of this gland. Occasionally when the tumor is in the vertex or superior wall of the bladder it may gradually extend through the wall so that the intestine becomes attached, and may subsequently result in a

vesico-intestinal fistula. Such a communication was present in 3 of our cases. The rectum is rarely invaded, although it may become adherent to the posterior wall of the bladder. Invasion of the vagina in women is said to be even more rare. When an invasion of the seminal vesicles occurs there is usually also at the same time an invasion of the prostate.

TUMORS OF CONNECTIVE-TISSUE ORIGIN.

Sarcoma.—All writers are agreed that primary sarcoma of the bladder is an extremely rare tumor, and in our series of 180 cases only 2 were encountered. Out of 89 tumors of the bladder examined microscopically by Albarran there were 2 sarcomata. The tumor occurs in the very young, but more frequently beyond the middle period of life. The tumor is practically always sessile. The surface is ordinarily smooth, although one observes occasionally villous vegetations, as in other vesical tumors. The tumors are usually single, but may be multiple. There is very little in the surface appearance of the tumor which serves to distinguish it from the malignant epithelial types, and usually the diagnosis can only be made from microscopic study. The tumors invade quite extensively the bladder wall, and are usually looked upon as quite malignant. All of the secondary complications, such as cystitis, ulceration, etc., may occur in sarcoma. The microscopic appearance does not differ from that of sarcoma in other portions of the body. One of our 2 cases was a patient, aged fifty-eight years, who gave a history of hematuria for two years. Cystoscopic examination showed an irregular, lobulated, dark red tumor in the left half of the bladder, about 4 cm. from the ureteral orifice. The surface of this tumor showed ulceration in places. A piece of tissue was removed by Young's cystoscopic ronguer. Microscopic examination showed small round-cell sarcoma. The tumor was excised suprapubically, with a large area of bladder wall. The convalescence was uneventful and the patient is well today, nine years after operation.

The other patient is a man, aged fifty-four years with an ulcerated tumor mass on the right side of the trigone encroaching upon the vesical orifice. A specimen was obtained by the cystoscopic rongeur which on microscopic examination showed a spindle-cell sarcoma. The patient is being treated at the present time with radium.

Myxoma.—Myxoma occurs most frequently in young people, generally in childhood. One case is reported by Winckel, quoted by Clado, in which the neoplasm was found in the bladder of a girl, dying thirty-six hours after birth. It is about equally frequent in both sexes. It generally presents itself in the form of a pedunculated tumor, more rarely sessile. The size is variable. It may be very small or it may attain quite large dimensions. Sometimes the tumors are multiple, and when they are they are usually quite small. Usually when the

tumors are multiple they are closely united at the base and have more or less the same point of attachment. The surface of the tumor may be smooth or lobulated; rarely it is covered with villi similar to those seen in papillomata. When there are numerous small tumors which have a common pedicle the neoplasm resembles somewhat a hydatid mole or a bunch of grapes. Thompson has described such a case. The pedicle is variable—sometimes long, sometimes short—and may be very slender or quite thick. The myxomata of the bladder present an appearance somewhat similar to the mucous polyps of the nose. Like the nasal polyps they are translucent. The consistency is soft. Ulceration is exceptional. The tumors have a preference apparently for the base of the bladder and the trigone, more frequently the trigone.

The vessels in myxomata of the bladder are more numerous than in myxomata of other organs. The surface of the myxomatous tumors is usually covered by the vesical mucosa. The tumor recurs quite frequently if its base has not been completely removed.

Fibromyxoma.—The microscopic appearance of this neoplasm differs very little from the pure myxoma. It has not the tendency to form the multiple lobules which give the appearance of a bunch of grapes. It usually occurs in the form of a polyp and the surface is smooth. This tumor may grow to great dimensions.

Symptoms.—*Hematuria.*—The most prominent and frequently the first and only symptom of vesical tumor is hematuria. In 156 of our cases it was the first symptom noted in 117. While there is nothing absolutely diagnostic about the hematuria which occurs from a tumor of the bladder, the sudden appearance of blood in the urine without other symptoms, especially when fairly profuse, should at once arouse suspicion and call for investigation. It may come on suddenly, at any time, independent of exercise or diet, and cease as quickly as it started. Sometimes it tends to be more or less continuous over a long period or it may be intermittent; the period of intermission may vary from a few hours to many years. Not infrequently patients are seen with a history of hematuria some years previous, then a lapse of years during which no blood was noticed, and finally, on the reappearance of the hematuria, a tumor is discovered, far advanced and sometimes hopelessly inoperable. The degree of hematuria is not indicative of the size of the growth. At times one will see a very tiny papilloma bleed so continuously and profusely that the patient becomes almost exsanguinated. We have seen a patient with a papilloma only a few millimeters in diameter bleed profusely over a period of a year and a half, and finally have a hemorrhage so severe that the hemoglobin dropped to 16 per cent. and transfusion became necessary in order to save life. On the other hand, a tumor almost filling the bladder may be associated with little or no hematuria, and, occasionally, one will see patients with large, inoperable growths in whom hematuria has never been a symptom. This, however, is rare. The color of the urine varies from a bright red (if the hematuria is profuse and the

bleeding fresh) to dark, coffee-ground color (if it is retained in the bladder on account of prostatic hypertrophy, stricture or the result of obstruction to urination from the tumor itself). At times it will be noted that the bleeding is more profuse at the end of urination. The severity of the hematuria is no indication of the benign or malignant character of the growth. When, however, the hematuria is more or less continuous, experience has shown that the tumor is more apt to be malignant. Hematuria is such a frequent, often the only, symptom of bladder tumor, particularly in its early stages, that its occurrence should demand a cystoscopic examination. According to Albarran it was the first symptom in 148 out of 200 cases studied by him, and in 117 out of 156 of our cases. Almost invariably if the first hematuria caused by bladder tumor is investigated it will be found that the tumor is of small size, and therefore offers the best opportunity for cure. The larger the size of the tumor the older it is, and therefore the more apt it is to be malignant. Casper states that in only three of his series of 142 cases was the tumor of large size when examined shortly after the first hematuria. Two of these were several inches in diameter and the third patient had multiple tumors which filled three-fourths of the bladder. In Albarran's series of 200 cases referred to, hematuria was the initial symptom in 57 of 62 cases of papilloma, 70 of 100 cases of carcinoma, 18 of 28 cases of sarcoma, and 3 out of 9 cases of myoma. In our cases it was the initial symptom in 60 out of 67 cases of papillomata and in 59 out of 83 cases of carcinomata. From this it will be seen that hematuria is the initial symptom in 77 per cent. (246 of 319) of the common tumors of the bladder—namely, papilloma and carcinoma—and in 62 per cent. of the sarcomata. It is present in about one-third only of the cases of myoma, etc., but the latter groups are extremely rare and of only slight practical importance.

Pain.—The next most common symptom of vesical tumors is pain or dysuria. It is usually a variable symptom. It is many times absent in benign tumors and not infrequently in malignant growths, even when extensive and of long duration. When present it varies from a slight feeling of uneasiness felt in the suprapubic region to a severe, constant, agonizing pain felt over the whole bladder. The pain may also be radiating in character, extending down the thighs and legs, due to the extent of the growth to the pelvic nerves or to the presence of spinal metastases. The pain ordinarily felt is due either to irritation of the growth itself, the accompanying cystitis, or to obstruction to urination. The extension of the growth into the bladder wall is sometimes accompanied by an intolerable cystitis, and this is particularly true of the type of tumor, which is characterized by infiltration of the bladder wall rather than by growth into the vesical cavity. In fact, the presence of intractable cystitis complicating vesical tumor is almost proof positive of malignant infiltration of the bladder wall. Associated with pain there is often present frequency

of urination. This symptom is due to the cystitis, residual urine, or contracture of the bladder.

Obstructive Urinary Symptoms.—When the tumor grows close to the vesical orifice it may give rise to mechanical obstruction, occasioning difficult urination or even complete retention. The symptoms in these cases are frequently not unlike those seen in cases of prostatic obstruction. When the tumor occupies this position, hematuria is apt to be a prominent symptom. Occasionally the patient consults a physician for the first time because of the symptoms of urinary obstruction. It is not infrequently a late symptom when the growth has become very extensive.

Renal Symptoms.—Usually when the growth involves one or other ureteral orifice (Fig. 17) obstruction to the ureteral flow is produced, with resultant hydro-ureter and hydronephrosis, while infection frequently supervenes with the production of pyonephrosis. In several of our cases severe pain in the kidney region was a very prominent symptom, due to an obstructing growth around the ureteral orifice. In the malignant and extensive growths on the trigone, renal infection and obstruction are not uncommon in the terminal stages.

Constitutional Symptoms.—Regardless of whether the tumor is benign or malignant, if its growth is unrestricted it sooner or later leads to the death of the patient from loss of blood, infection, renal insufficiency, or cachexia. Even when the growth is malignant a splendid degree of health may be maintained over a number of years. In one of our patients a malignant growth was excised, the operation being followed by recurrence. Two subsequent suprapubic excisions were performed, and eventually the bladder became almost completely filled with tumor masses. The patient finally died eleven years after his first operation of a myocarditis, his general health and nutrition being well maintained. While in some cases the general carcinosis occurs late, in others it is extremely early. The occurrence of pain in the bones, and especially along the course of the spinal nerves in a patient with vesical tumor, should always excite suspicion of metastasis. When these symptoms are present, a Roentgen-ray examination should be made before undertaking any radical procedures, even though the condition of the patient and the appearance of the growth would seem to offer a favorable prognosis. The Roentgen-ray examination will not infrequently reveal the presence of a bone destruction which will render useless the radical excision.

Diagnosis.—The cystoscope has rendered the diagnosis of bladder tumor quite simple in the vast majority of cases. Other methods of examination, such as rectal examination, abdominal palpation, and the employment of the Roentgen rays with the bladder filled with thorium or other suitable substance frequently give information of value regarding the extent, position, and nature of the growth.

Palpation.—Occasionally when the bladder is extensively involved by an infiltrating form of growth and the abdominal wall is thin and

soft the hard, irregular mass can be detected. When malignant growths occur on the posterior wall of the bladder or posterolateral wall, rectal examination very frequently gives most valuable information regarding the nature of the growth and its extent, and frequently determines the possibility of complete eradication by operative procedures. When the growth infiltrates the bladder wall, induration can be detected and the extent of the bladder wall involvement more or less accurately mapped out. The value of rectal examination in cases of vesical tumor cannot be too strongly emphasized. About 50 per cent. of bladder tumors occur on the posterior bladder wall in a position accessible to the examining finger. Sometimes not only is the induration detected in the bladder wall but the seminal vesicles and the prostate are also involved. In rare instances the growth may extend through into the rectum and a rectovesical fistula result. This occurred in 3 cases in our series. It may be safely said that marked induration of the bladder wall which is felt through the rectum is strong evidence of carcinoma. In the female valuable information regarding the condition of the posterior bladder wall may be obtained by vaginal examination.

Examination of Urine.—The urine in cases of vesical tumors varies. When the hematuria ceases the urine, especially in early papilloma, may be perfectly clear and normal. Often, however, cystitis complicates the newgrowth, particularly if it be malignant, the degree varying from slight turbidity to the dirty, foul-smelling condition of the urine frequently seen in advanced stages of cancer. Ultzmann describes the condition, which he calls fibrinuria, in which the urine contains a large quantity of thick, ropy, gelatinous mucus which is so viscid that it sticks to the sides and bottom of the inverted glass. He claims that he has never seen this condition except in cancer of the bladder. We have observed a similar condition in severe grades of cystitis due to other causes. Occasionally the urine contains detached tumor particles; many times pieces large enough for microscopic section are detached, and it is possible sometimes to determine the benign or malignant character of the growth from the specimen thus obtained. With the exception of the blood and the occasional finding of tumor particles there is nothing in the urine particularly characteristic.

Cystoscopy.—The cystoscope is by far the most precise method for determining the presence or absence of a vesical growth. By means of the cystoscope not only the presence of a neoplasm can be determined, but the appearance, location, size, and number can be ascertained. In many cases the malignant and benign character of the growth can be differentiated and the form of treatment best suited to the individual case determined. Many variations of cystoscope are successfully employed, but in the majority of cases the use of the irrigating type will be most satisfactory. Occasionally on account of severe hematuria, it may be impossible to clear the field sufficiently to obtain a perfectly satisfactory examination. Difficulty in obtain-

ing a clear field is itself very suggestive of neoplasm, providing trauma has not been produced in the introduction of the instrument. Even in the presence of profuse bleeding it is nearly always possible with the irrigating type of cystoscope, the irrigation being continued while the examination is being made, to obtain a momentary view of portions of the bladder and determine the presence of a newgrowth. The greatest difficulty will be encountered when the neoplasm involves the vesical orifice, because the introduction of the instrument will often produce such free bleeding that no view can be obtained. In several cases when this occurred on removing the cystoscope small pieces of tumor were found attached to the end of the instrument. Occasionally several attempts may be necessary before a satisfactory examination can be obtained. When a satisfactory view cannot be obtained on account of the bleeding, the introduction of a retention catheter for a few days, thus putting the bladder at rest, will frequently cause such a change in the conditions present that a satisfactory cystoscopy can then be made. We have found this useful in several cases. Sometimes the introduction of a little adrenalin (about 1 to 5000) will cause a temporary cessation of the hematuria and enable one to obtain a view. Small tumors at the vertex of the bladder may be readily overlooked when the indirect cystoscope is employed, so that preferably an instrument which allows both direct and indirect views should be used, as only in this way can a complete survey of the entire bladder be obtained.

Appearance of Papilloma.—The cystoscopic appearances of papillomata are quite characteristic. One type of growth has a villous surface and the individual villi are observed waving in the fluid. At times the villi are long and slender and the bloodvessels can be seen coursing through the papillæ. At other times the papillæ are shorter and thicker. The long, slender papillæ are usually pale, while the shorter, stubbier ones are pinkish or red. Sometimes pulsation of the entire tumor is observed. Occasionally little bleeding-points may be seen. In other types the villi are stubby and close-set, giving the tumor a raspberry-like appearance. Sometimes the tumor surface, instead of being papillary, is comparatively smooth and apparently composed of varying size lobules. These tumors are usually quite red.

There is a rather rare form of papilloma in which the individual villi spring independently from the bladder mucous membrane instead of from a definite pedicle. This gives the appearance of a sessile growth and leads to suspicion of malignancy. While the pedicle of the papilloma is rarely distinctly visible, often the tumor mass can be seen to sway as a whole in the fluid, which indicates its pedunculated character; and at other times it is possible to view slightly beneath the mushroom-like edge of the tumor. It is impossible from the cystoscopic appearance of papillomata to determine whether they are benign or malignant. When, however, the malignant changes are

so far advanced that infiltration of the bladder wall has occurred, there are certain cystoscopic appearances which nearly always enable one to arrive at a fairly accurate diagnosis. The presence of necrosis in the papillæ is indicative of carcinoma, and is usually associated with invasion of the underlying bladder wall. In the earlier stages when the malignant papilloma has just begun to invade the bladder wall it may not be possible cystoscopically to determine this point, but when the process is at all advanced the tumor loses the pedunculated character and becomes sessile in type. Frequently around the margin of the tumor is seen edema or bullæ which is usually indicative of a cancerous invasion of the bladder wall below. At other times little tumor nodules can be seen beyond the main tumor growth. This again is indicative of malignancy. While it is impossible to definitely describe all the appearances which serve to diagnosticate the papillary carcinoma from the papilloma, the cystoscopist of experience usually is able to differentiate them, and it is interesting to note how frequently the cystoscopic diagnosis proves to be correct. In the scirrhous or lobular form of carcinoma the diagnosis is seldom difficult. The cracked, fissured surface, the broad base (the base frequently being broader than the surface) and ulceration, are appearances so characteristic that the diagnosis is comparatively easy. In the concentric type of Albarran or the infiltrating type, in which the tumor infiltrates extensively the bladder wall without projecting into the bladder cavity, the diagnosis may be extremely difficult and the disease may be mistaken for severe cystitis with contracted bladder. In 2 cases of this type examined cystoscopically the bladder simply gave the appearance of extensive and severe ulceration and other evidence of intense cystitis. The occurrence of ulceration, necrosis, or incrustation of the tumor with urinary salts is very strong evidence of malignancy, as these practically never occur in benign papilloma. Occasionally, owing to severe cystitis in a small and intolerant bladder, cystoscopic examination may be impossible, and in such cases when rectal examination and other means fail to give a positive diagnosis as to the condition the employment of Roentgen-ray examination with the bladder filled with 10 per cent. thorium solution will sometimes reveal the true condition. Again, this method may be used in determining the presence or absence of infiltration of the bladder wall when a satisfactory cystoscopy is impossible. When the bladder wall is deeply infiltrated on filling it with fluid the wall, being thickened at the point of infiltration, does not expand in its usual rounded form as does the normal bladder wall (Fig. 73). At times even the pedunculated nature of the tumor can be brought out with striking clearness in the cystogram.

Excision of Piece of Tumor for Diagnosis.—For a number of years we systematically removed pieces of bladder tumor by means of the Young cystoscopic ronguer, for the purpose of histological examination. The information derived from this method would seem to fur-

nish conclusive evidence of the nature of the tumor and consequently enable one to select accurately the type of treatment best suited to the tumor in question. Unfortunately the evidence derived is not always conclusive because of the fact that the portion removed is not always a safe index of the character of the remainder of the tumor. The piece removed may show none or very few malignant changes while other

FIG. 73.—X-ray picture of bladder injected with bismuth subnitrate suspended in water. Diagnosis: Papilloma of bladder; note detail in form and surface. *A*, *A*, *A*, are the tumors; *B*, is the bismuth; *C*, air let into bladder before injecting. (Kelly and Burnam.)

portions of the tumor may be definitely carcinomatous. When the piece of tumor excised, however, shows definite carcinoma the employment of radical procedures suitable for the individual case should be adopted without delay, and valuable time not lost in the employment of the usual endovesical methods of treatment. The excision of a piece of tissue will also prove of value in differentiating the different

types of vesical tumors. It should be noted, however, that the removal of tissue by this means has been criticized as increasing the risk of metastasis. This has not been our experience, however, and the information obtained frequently counter-balances the theoretically increased risk of metastasis.

Sarcoma.—This is a comparatively rare form of bladder tumor and was only observed twice in our series of cases. In both instances the tumor was an ulcerated growth and could only be differentiated from an ulcerative type of carcinoma by microscopic study.

Adenoma.—This is an extremely rare tumor and occurred twice in our series of cases. One patient, a colored man, aged forty years, had no symptoms referable to his bladder. The tumor was discovered

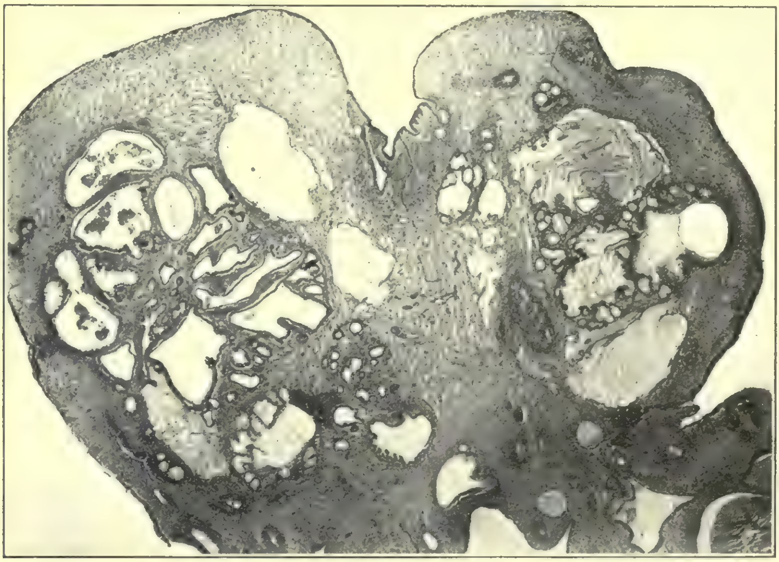

Fig. 74.—Section of a cystic adenoma, low power.

accidentally upon cystoscopy. It was present on the trigone and surrounding the vesical orifice, the surface being lobular and edematous-looking. A piece of the tumor was removed by the operating cystoscope and sections showed it to be a benign adenoma (Figs. 74, 75, 76). Patient refused treatment and was seen again six years later. The tumor had become considerably more extensive and covered more of the trigone, but was not producing any urinary difficulty, and there had been no hematuria.

Cysts.—The cystoscopic appearance of cysts is quite characteristic. They usually occur close to the vesical orifice, and when a satisfactory examination is obtained they are seen to be translucent and one readily determines that they are filled with fluid. We have had four

of these tumors. In each instance the symptoms were those of obstruction, owing to the position of the cyst obstructing the outflow of urine.

Myxoma, myoma, and fibroma are so rare that cystoscopic diagnosis of the nature of the tumor would not be possible.

Adenocarcinoma.—There have been two of these among our bladder tumors and, in both instances, the tumors were slightly elevated, flat, ulcerated growths, with deep infiltration into the bladder wall. The

FIG. 75.—Higher magnification, same tumor, showing cystic dilatation of vacuolated cells of acini.

cystoscopic appearance was quite positive of malignancy in each instance.

The differentiation between benign and malignant papilloma, so far as the selection of treatment is concerned, is of little practical value because fulguration has proved efficient in each form. It is, however, of importance to be able to differentiate between the papilloma and the papillary carcinoma because fulguration or radium is apparently not suited for this latter type of growth and radical exci-

sion offers the only hope of cure. The removal of small pieces of tumor for microscopic section will in some instances be of value. In other cases, however, it may be quite misleading. We have observed several cases in which the surface of the tumor was like that of a papilloma and tissue obtained with the operating cystoscope for microscopic study presented a picture in no way different from the average, slightly malignant papilloma. Rectal examination, however, showed that the deeper portions of the tumor had infiltrated extensively the bladder wall, and the subsequent course of the cases confirmed this diagnosis of advanced malignancy.

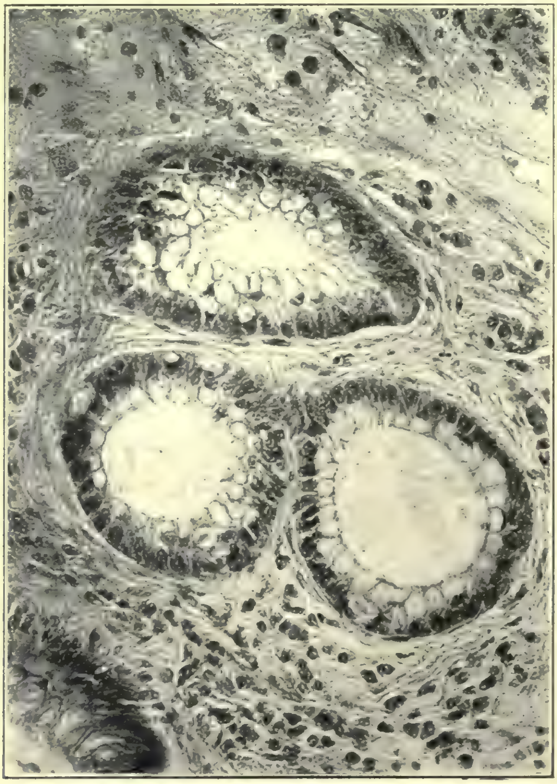

FIG. 76.—High-power magnification of same acini.

It is seldom that much difficulty will be realized in determining the presence of a neoplasm in the bladder. The employment of cystoscopy, palpation, rectal examination, radiography, and the consideration of the symptoms will make the diagnosis certain for the urologist of average experience.

Treatment.—*Endovesical Treatment.*—Before the introduction of fulguration and radium, operative cystoscopy for the radical removal

of benign tumors was not only practised but considered the best way of handling these growths by several well-known authorities, notably Nitze and Casper. Nitze, after he had perfected his simple observation and ureter catheterizing cystoscope, devoted his genius to the development of an operating cystoscope, with which he was able to obtain results that were superior to the suprapubic method of removal.

Fig. 77.—Interior of the bladder with four benign papillomata showing on its surface and showing the typical villous surface often seen in these neoplasms. (Watson and Cunningham.)

Nitze reported 150 cases of tumors of the bladder treated by his operating cystoscope, with only 1 death and 20 recurrences, a record which no one has been able to duplicate. The removal of tumors of the bladder through the urethra is a procedure long practised.

Civiale and Leroy d'Etiolles were the first to attempt the removal without opening the bladder.

Antal removed the tumor by means of a lithotriptor instrument

after he had previously determined the seat of the growth. Gruenfeld was the first to operate in the bladder under direct control of the eye. He employed a simple endoscopic tube, with which he was able to see small tumors and either to partially or entirely remove them. All of these attempts were more or less futile until Nitze introduced his operating cystoscope. Since Nitze's work there have been many instruments introduced for the cystoscopic treatment of vesical tumors. Nitze employed a cystoscope, through which he could pass his operating device, containing at its end a wire loop with which the tumors were covered and then cauterized. He also had what he called his lithotriptor, an instrument with blades like a lithotrite, with which small tumors could be removed. Another attachment in

FIG. 78.—Mucous polyps (myxosarcoma) in a girl.

the shape of forceps was used to obtain small portions of the growth for microscopic section. The older endovesical methods of treatment never attained any general use on account of the difficult technic which their employment entailed. This method of treatment could not be successfully employed in the vast majority of cases.

Fulguration of Tumors.—In 1910 Edwin Beer reported a method of treating vesical tumors which has proved a distinct advance. The method was immediately taken up by American surgeons and now is receiving recognition abroad. This method has received various names, such as fulguration, high frequency, desiccation, electrocoagulation, etc. None of these terms is exactly appropriate, but the term fulguration has now become the most common.

Fulguration Apparatus.—Various types of apparatus for fulguration have been devised. The one manufactured by the Wappler Surgical Instrument Company, of New York, has been found very satisfactory. In our work the unipolar, or Oudin, current has been employed almost exclusively. It is rather generally conceded, however, that the bipolar, or d'Arsonval, current is more penetrating and destructive, but that for this reason considerable care must be exercised in its use. The unipolar current is the form most commonly employed. It will also be found more satisfactory to have the cystoscope lighted by means of a dry-cell battery. There will be less trouble from electric shocks to the patient and short-circuiting of the current in the cystoscope if the cystoscope and high-frequency machine receive current from different sources of supply.

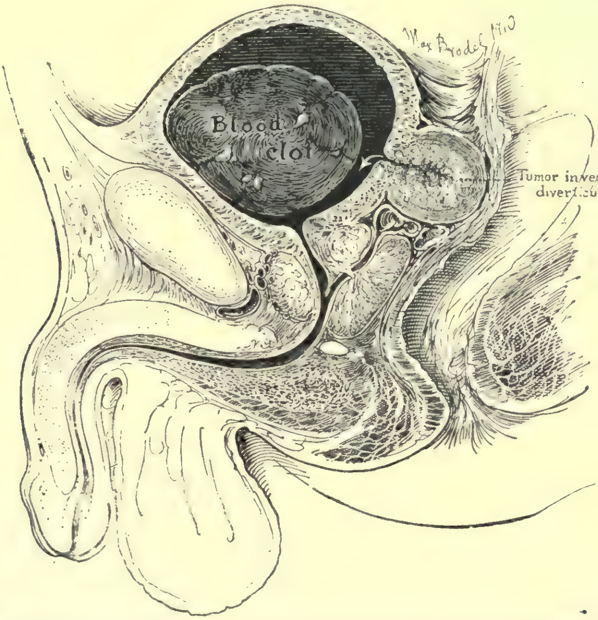

FIG. 79.—Sagittal view showing carcinoma which has developed in diverticulum of posterior wall of bladder. (Kelly and Burnam.)

Technic.—Application.—The patient is placed in the usual position for cystoscopy and a catheterizing cystoscope is introduced in the ordinary way. The electrode is passed along the catheterizing telescope, similar to the passage of a ureteral catheter. The tumor is located and the electrode is held up against the most accessible portion of the tumor mass. It can be buried either in the depths of the tumor or touched lightly against the surface. The position of the electrode should be changed frequently and each portion fulgurated from ten to thirty seconds. In our experience more effective results are obtained

when the electrode is held a slight distance from the tumor surface so that a definite sparking is obtained, a greater destruction of the growth resulting from this technic. The duration of the treatment will vary with the size and character of the growth and the tolerance of the patient. When the insulated steel wire is employed the heat produced at the point of contact will melt the insulation, and it is advisable occasionally to remove the electrode and clip the end so that the wire is flush with the insulation. Newer forms of electrode with brass end or bone tips obviate the necessity of withdrawing, clipping off, and reinserting it. The frequency of the treatment varies

FIG. 80.—Rhabdomyosarcoma in a child. The bladder is opened from above, showing the lobulated mass of tumors. (Watson and Cunningham.)

with the patient and the discomfort produced by the operation. Most patients will tolerate a treatment about every five days. In some tumors, particularly the long pedunculated variety, it is possible to insert the wire into the pedicle, and in this way destroy the growth more rapidly. If the tumor is bleeding the point of hemorrhage should be located if possible and fulguration applied over this area. This usually causes cessation of the bleeding and simplifies the further treatment of the tumor. When the electrode is applied there is an almost immediate whitening of the tissue, with a rapid formation of gas bubbles and when buried in the tissue and left there for some

time, charring at the point of contact occurs. The application of the current to the tumor itself is usually painless, in sharp contrast to the severe pain produced when the electrode is resting on the mucous membrane of the bladder.

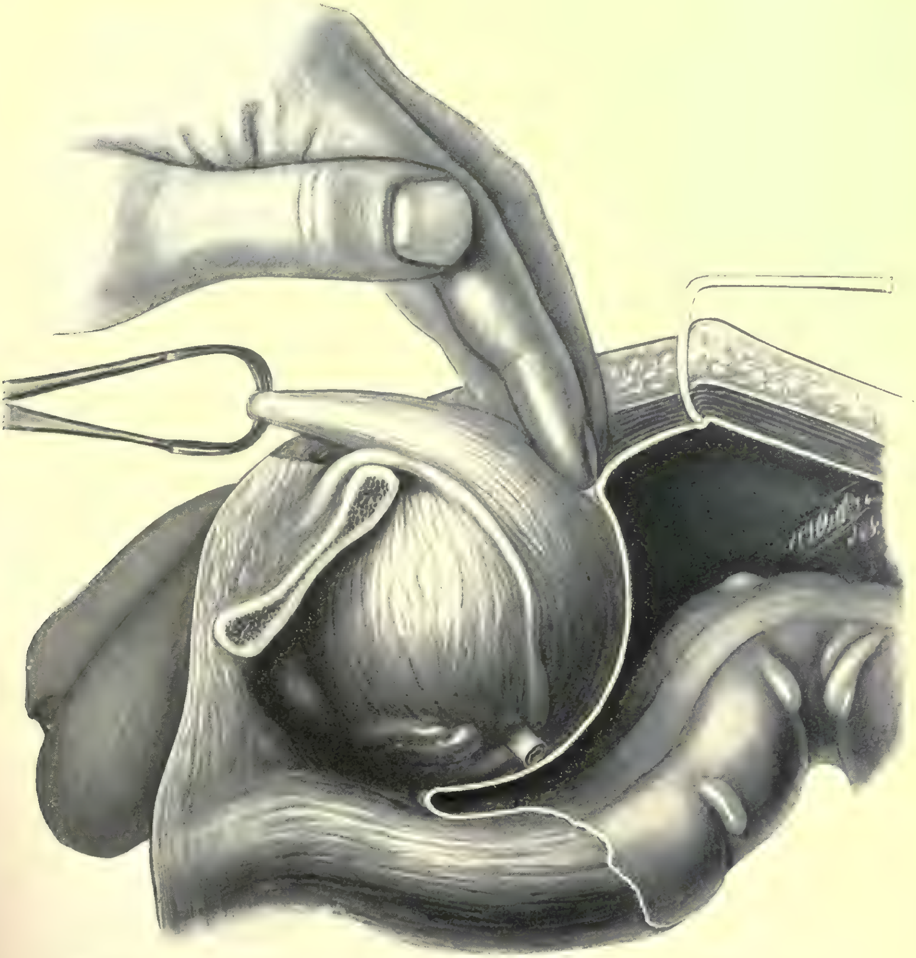

Fig. 81.—Total extirpation of bladder. First step. (Watson and Cunningham.)

The spark gap should be about 0.5 cm. in length. It has been our experience that too strong a current has a tendency to burn off the insulation of the electrode and the result is a short circuit in the cystoscope. Furthermore, when the current is too strong it frequently results in rather profuse hemorrhage from the surface of the tumor and renders satisfactory treatment impossible.

Fulgurating Sound.—Cystoscopic difficulties are occasionally encountered which render the usual technic unsatisfactory. The occurrence of the tumor around the vesical orifice, particularly if it be large or the bladder irritable, may make the application of the treatment in the ordinary manner difficult or impossible. For these cases the fulguration sound devised by Young has proved eminently satisfactory. The sound is passed into the bladder and the tip placed against the

Fig. 82.—Total extirpation of bladder. Second step. (Watson and Cunningham.)

tumor, the point of contact being changed frequently. The production of severe pain is an indication that the mucosa of the bladder is being fulgurated and its position should be changed immediately. Before using this sound one should have an accurate idea of the size and location of the tumor, and it should be used with great caution to avoid burning the bladder mucous membrane. When skilfully used it is frequently possible to destroy a sufficient amount of the tumor to allow subsequent fulguration with the cystoscope.

Tumors Suitable for Fulguration.—Some confusion exists concerning the types of bladder tumors suitable for fulguration. There is a more or less general agreement that fulguration of the hard, lobular, infiltrating carcinomata results in more harm than benefit; but that this treatment, on the other hand, for typical benign papilloma, yields results immeasurably superior to that obtained by any other procedure. Uncertainty exists regarding the possibilities of fulguration

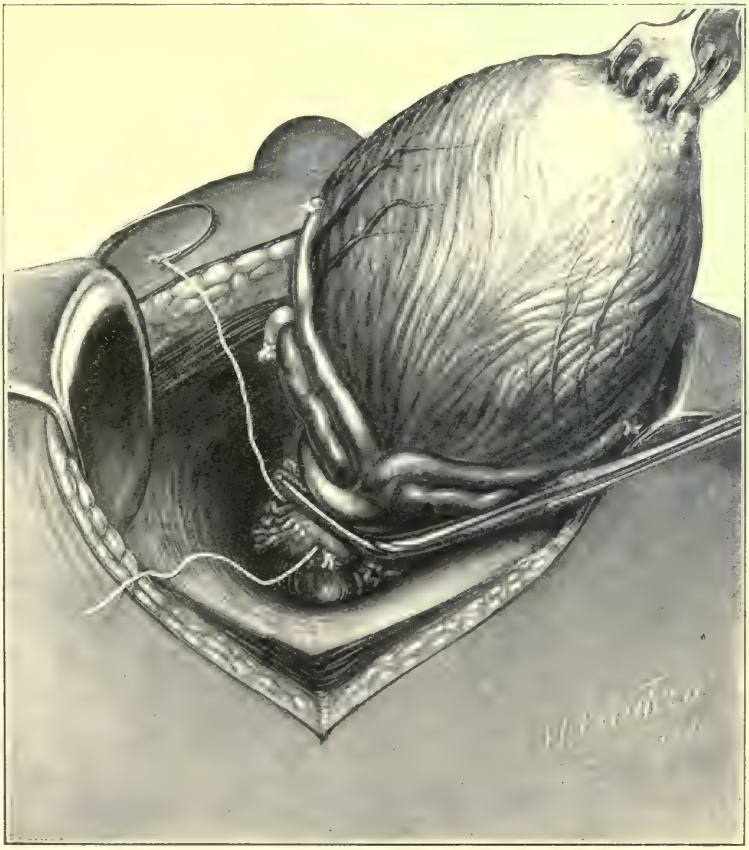

FIG. 83.—Total extirpation of bladder. Third step. (Watson and Cunningham.)

for malignant papillomata and for the diffuse papillary and sessile tumors which are carcinomatous. Beer states that the high-frequency treatments are particularly applicable to the benign papillomata, but numerous surgeons have reported the apparent cures of tumors pronounced malignant by the pathologists. Others question the ability of the pathologists to decide between the benign and malignant nature of the papilloma and consider that the nature of the growth is to be

decided not upon its histological characteristics, but upon its manner of response to fulguration.

In 68 cases of bladder tumor seen in the past four years in the urological clinic of Johns Hopkins Hospital fulguration has been employed in 47. In 36 of the 47 cases the tumors were papillomata. In 10 cases the tumors were either hard, lobular, infiltrating carcinomata or diffuse papillary carcinomata associated with more or less extensive infiltration of the bladder wall. Of the 36 papillomata a histological study of the tumor was made in 25 cases. Of these 25, 8 were typical benign papillomata and 17 malignant papillomata of varying degrees of malignancy histologically. The Oudin or unipolar current was employed in practically all of the cases because it seemed just as efficient and destructive as the bipolar.

Results in the Benign Papilloma.—Of the 8 cases of benign papillomata examined histologically, in only 1 case was there more than one tumor present. This patient had one large tumor near the left ureter with numerous small implantations around the vesical orifice. In 7 of the cases the tumor disappeared after two to five treatments, the tumors varying in dimensions from 0.5 to several centimeters. In 1 case, with a large papilloma, the patient did not return for treatment after the second application.

Results in Papillomata not Examined Histologically.—In this series there were 11 cases, and all had single tumors with one exception. This patient had 17 small papillomata, scattered over various portions of the bladder, being recurrences of a papillary tumor excised suprapubically a year previous. The tumors were all small and were destroyed in four applications. In 7 of these cases the tumors were cystoscopically of the benign type; they were definitely pedunculated and had very fine delicate papillæ. In all of these 11 cases the tumor disappeared entirely, and in none up to the present time has a recurrence been observed in the bladder, although 1 patient has since died of carcinomatous metastases. This case is of particular interest. The patient, aged forty-eight years, had a history of hematuria for several years. He consulted a surgeon who diagnosed the condition bladder tumor and advised suprapubic drainage for relief of urinary symptoms, because the tumor was considered inoperable. At operation a large papillary tumor was found on the left lateral wall of the bladder, and nothing was done except to establish a suprapubic fistula. He was seen about four months after this operation, and it was decided to try the effects of fulguration, although very little hope of a successful result was entertained. The tumor was vigorously fulgurated through the suprapubic fistula and through the urethra by means of the Young fulgurating sound, and later direct fulguration through the cystoscope was carried out. He was also treated by radium through the suprapubic fistula. At the end of two months no tumor could be seen in the small contracted bladder, and it was decided to close the suprapubic fistula, a procedure which was carried out. At operation

the most careful search of the bladder failed to show any evidence of tumor, and small pieces of bladder wall snipped off from various portions and examined microscopically failed to reveal the slightest indication of any neoplasm. For the next nine months the patient was entirely comfortable except for frequent urination occasioned by his contracted bladder. Examination then showed, however, evidences of carcinoma of the prostate, which was the result of a metastasis or of implantation of the original tumor. Subsequently he developed spinal metastases and died eighteen months after the disappearance of the bladder tumor, although there developed no recurrence locally. No tissue was obtained in this case for microscopic examination, but the end-result proves very conclusively that the tumor was malignant.

Results in Malignant Papillomata.—In 7 of the 16 cases in which a histological diagnosis of malignant papilloma was made the tumors were multiple. In 1 of these cases more than 100 small tumors, varying from 1 mm. to 0.5 cm. were scattered in all portions of the bladder. In this case 3 large malignant papillomata had been removed suprapubically a few months previously, and these tumors represented recurrences. In another case the bladder mucous membrane was literally completely covered with papillomatous tumors so that one could see but small portions of mucous membrane even when the bladder was opened. Five of these 16 tumors had been treated by operative procedures of varying kinds, either resection, excision with clamp and cautery or cauterization with the actual cautery. In 11 cases the tumors were entirely destroyed. One patient died while under treatment, but the tumor in this case had almost disappeared. In 2 cases the tumor resisted treatment absolutely, although in each instance it was small and was frequently and vigorously burned. In both cases examination of the tissue obtained showed tumors very malignant in character with definite infiltration of the connective-tissue axis. In one the tumor seemed rather to be stimulated in its growth by fulguration than otherwise, reaching several times its original size before cessation of treatment. A successful resection was subsequently performed and the patient has now been well over four years. The other patient developed multiple tumors and died of a cardiac condition following a senile dysentery. In another case, because of the weakness of the patient and a severe myocarditis, treatment was discontinued after a sufficient number of tumors had been removed from around the vesical orifice to permit freedom of urination. This patient had a markedly contracted bladder and had had three previous suprapubic excisions of multiple papillomata. He died a few months later of the cardiac condition. The tumors in this case were very responsive, and if treatment could have been continued it would have been possible, most probably, to have removed all of them. In another case, in which the bladder mucosa was completely covered with papillomata of varying sizes, it was decided to open the bladder and apply fulguration. This was carried out, the tumors being sparked

with a strong current for a period of forty-five minutes. About ten days later the patient was again anesthetized, and it was found that with the exception of a few small papillomata, the tumors had entirely disappeared. The remaining tumors were then vigorously fulgurated. Subsequent examination of the bladder a few weeks later showed no signs of tumor. About six months after leaving the hospital the patient was again seen, examination at this time revealing several papillomata in various portions of the bladder. He refused further treatment. Up to the present time there has been a recurrence in 4 cases, in which the tumors had been previously removed. Two patients whose tumors disappeared under fulguration have since died with carcinomatous metastases, in 1 case one year and in the other fourteen months after the tumor had been destroyed. The histories of these 2 cases are as follows:

Case 1.—Male, aged fifty years. History of hematuria for three years previous to his examination. Cystoscopy showed a small papilloma on the right lateral wall and a group of 7 papillomata covering a large portion of the left lateral wall and extending so as to partially obscure the left ureteral orifice. The tumor on the right lateral wall was destroyed by two fulgurations. The tumors on the left lateral wall were very resistant, and at least twenty-five treatments, vigorously applied, were necessary before the last vestige of tumor disappeared. A period of almost six months was occupied in the removal of these tumors. About two months after the last trace of tumor had been destroyed, a small recurrence, about the size of a pin-head, was discovered back of the trigone. This was readily removed. Some weeks later a similar recurrence was found. Although the patient was seen at frequent intervals during the next six months there was no evidence of recurrence on careful cystoscopic examination. At the end of this time, however, another tiny, pin-head size recurrence was noted, which was also easily and readily cured. The patient remained well until four months later, when he developed spinal metastases, the clavicle being involved also. He died about fourteen months after the original tumors had been removed.

Case 2.—Male, aged forty-five years. History of hematuria for four years. Cystoscopic examination showed a large papilloma almost filling the bladder and encroaching upon the vesical orifice so as to make urination extremely difficult and painful. On account of the position of the tumor and the severe urinary symptoms of the patient, suprapubic excision was decided on. On opening the bladder an enormous papilloma with a narrow pedicle and no infiltration of the base was discovered. This was removed with the Paquelin cautery and the base thoroughly cauterized. Six months after leaving the hospital several small papillary tumors were found in the region of the right ureteral orifice and were readily destroyed by fulguration. Examination nine months after operation showed a very marked cancerous condition of the prostate, although at this time the bladder

was entirely free of tumor. The patient rapidly developed spinal metastases and died eighteen months after the operation.

Recurrences.—Of the 36 patients in whom fulguration was successful in removing the original tumor or tumors, recurrences are known to have occurred in 8. In all of these, with one exception, recurrence was present in less than a year. On one patient recurrences are observed every few months, although it has been over five years since the original tumor was destroyed. This tendency to recurrence seems as active today as it was during the first year. The recurring tumors, with one exception, have all responded to fulguration like the original tumor. The one exception is of extreme interest. This patient had a papillary tumor, 3 cm. in diameter, just back of the ureteral orifice, which disappeared fairly rapidly under a combination of radium and fulguration. For several months after the disappearance of the tumor the mucous membrane of the tumor-bearing area seemed entirely healthy. Shortly afterward, however, cystoscopic examination showed a peculiar reddening and some slight bulging of the mucous membrane without ulceration or definite tumor formation. This was at first thought to be a localized inflammatory area. The process, however, seemed to spread, and a piece removed with the cystoscopic rongeur showed the patient to have an infiltrating carcinoma of the bladder wall, with the mucous membrane on the surface practically intact. This is undoubtedly a case in which cancer cells from a malignant papilloma have metastasized into the bladder wall and there continued to grow after the tumor mass had been entirely removed. A malignant tumor of this type has been studied histologically by Buerger. Patients with multiple tumors seem more apt to have recurrences than those in whom only one tumor is present. While it is too early to draw definite conclusions regarding the percentage of cases that will remain permanently cured, the results to date seem to warrant belief that a not inconsiderable proportion will be free, because the tendency for recurrence grows progressively less after the first year.

Results in Hard Lobular Carcinomata and Papillary Carcinomata.—In this series there were 11 cases. Of these 3 were of the hard, lobular, infiltrating type, 2 were hopelessly inoperable, and the others had had extensive resections, and attempts were made to treat the recurrences. In none of these cases was the slightest benefit obtained from the treatment, and, furthermore, it was extremely painful. In 8 cases the tumors were papillary carcinomata with varying degrees of infiltration of the bladder wall. Three of these had been previously operated upon. In none was it possible to eradicate the tumor or to effect more than partial symptomatic relief. In several cases in which the tumor crowded around the vesical orifice, interfering with urination, it was possible to destroy sufficient of the tumor to render urination free.

Radium.—Radium has not as yet been employed in the treatment of bladder tumors in a sufficiently large number of cases nor for a

sufficient period of time to be able to draw absolute conclusions regarding its possibilities. In our experience the benign type of papilloma and the majority of the histologically malignant variety disappear also under fulguration. A certain proportion of the latter group, however, are very resistant and respond extremely slowly or not at all. This resistant type of tumor forms a very definite group and should be differentiated from the papillary carcinoma in which there is invasion of the pedicle or bladder wall. The cystoscopic and histological appearances of this group of papilloma differ in no way from the variety which is responsive to fulguration. In all of these tumors the coagulated tissue, resulting from the burn, separates in from one to two weeks, leaving a perfectly clean surface in contradistinction to the papillary carcinomata in which the sloughs following fulguration are apt to persist indefinitely. In 6 of our cases in which fulguration had been employed over long periods of time and in which the tumors had resisted very stubbornly all efforts to entirely destroy them, the effect of radium was most striking. After receiving from 400 to 500 milligrams of radium for an hour, the application being made directly against the tumors, the latter disappeared in each instance with astonishing rapidity. The following history illustrates the value of radium in these cases. The patient was a male, aged seventy-five years, with hematuria for several months. Cystoscopy revealed a papillary tumor, posterior to the right ureteral orifice. The tumor was about 1.5 cm. in diameter, and on histological examination proved to be of the malignant papilloma type. This tumor was vigorously fulgurated over a period of six months, at intervals varying from one to two weeks. At the end of this period the tumor was only slightly smaller than when first observed. It was then radiated at weekly intervals, 100 mg. of radium being applied directly to the surface of the tumor for periods of an hour. After five treatments fulguration was resumed, the tumor now disappearing entirely under one vigorous application. This patient died of pneumonia four months later and a careful postmortem examination showed no recurrence or metastases. Our results in the other 5 cases have been analogous to the one just cited.

When the tumors are infiltrating and definitely carcinomatous the results so far have been entirely negative and no disappearance of the tumor has been observed, or, in fact, any noticeable diminution in the size of the growth. In several cases of inoperable carcinoma with severe hematuria the radium has acted beneficially in causing a cessation of the hematuria, with subsequent comfort to the patient.

Technic.—Experience has proved that the direct application of radium to the surface of the tumor has resulted far more satisfactorily than its employment in much larger amounts through the abdominal wall. It has been shown experimentally that the potency of radium varies inversely as the square of the distance of the radium from the point to be radiated. In consequence of this, if radium is to be applied externally, say at a distance from the tumor ranging from 10 to 20

cm., a prohibitive amount is required in order to gain a similar amount of radiation following its direct application. The clinical results would seem to bear this out.

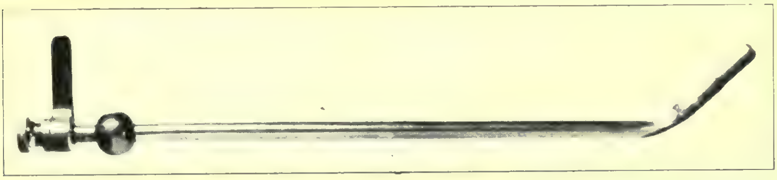

FIG. 84.—Radium instrument which is used for the treatment of tumors in the region of the vesical orifice and trigone. This instrument carries an observation cystoscope.

Young has devised several ingenious radium-carrying instruments provided with a cystoscopic barrel, by which accurate applications can be made to any portion of the bladder desired. The instrument

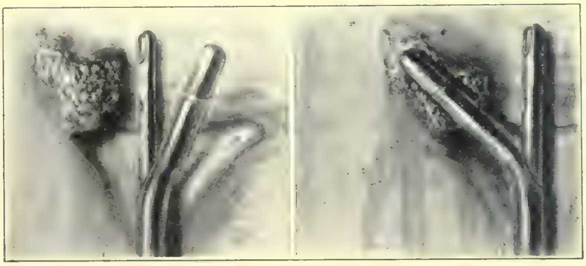

FIG. 85.—Showing the steps in the application of radium to a malignant papilloma in the region of the right ureteral orifice.

shown in Fig. 84 is used for tumors about the vesical orifice and in the trigonal region, while those shown in Figs. 86 and 88 are designed for cases requiring radiation of the lateral and posterior aspects of the

FIG. 86.—Instrument for the treatment of tumors on the lateral wall of the bladder. Its beak consists of two hollow halves in which the radium is placed.

bladder. The latter instruments, it will be seen, are readily introduced, after which, by a simple device, the plane of the radium is altered to coincide with the portion of the tumor requiring radiation.

The radium which is in solid form is contained in a small glass tube. Depending upon whether the gamma rays alone or a combination of

beta and gamma rays are desired the radium is carried in a closed platinum container or a fenestrated capsule. The platinum container is 3 mm. in thickness, an amount more than sufficient to filter out the beta rays. In cases in which both the beta and gamma rays are to be

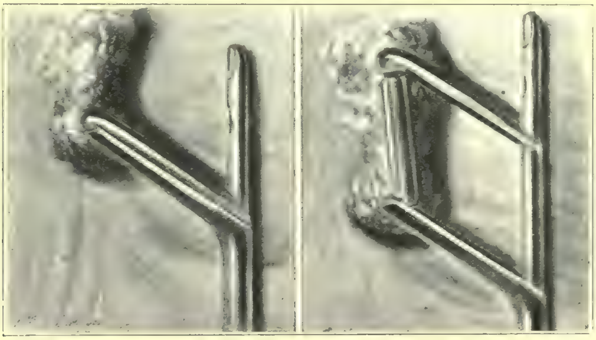

FIG. 87.—The instrument shown in Fig. 86 and the steps in the application of the radium to a tumor back of the ureteral orifice.

FIG. 88.—Instrument used for the treatment of tumor on the anterior and posterior bladder wall in positions not accessible to the other instruments.

FIG. 89.—Showing the application of radium to a malignant papilloma on the posterior wall with the instrument shown in Fig. 88.

used the fenestrated capsule is employed, the fenestra being applied directly to the tumor surface. In a few of our cases the gamma rays alone have been used, but it would seem from our experience that in the treatment of malignant papillomata which have resisted vigorous

fulguration that more rapid and effective results may be obtained by the utilization of both the beta and gamma radiations.

Operative Procedures.—*Suprapubic Cystotomy.*—Until very recently, practically all bladder tumors were attacked through the suprapubic route. After opening the bladder, various procedures were adopted, depending upon the size and multiplicity of the growths, the special preference of the operator and the cancerous or benign nature of the tumor. When the tumors were pedunculated some surgeons excised the tumor with a margin of mucous membrane, the edges of the mucosa being subsequently approximated by suture. By others the pedicle was seized with the forceps and the tumor twisted off at its base. Others again preferred to cut across the tumor at its base with the cautery or destroyed the tumor or tumors in their entirety by means of the actual or galvanocautery. No matter what method of removal was employed the results seemed equally discouraging and recurrences were so frequent that operative procedures, except under special circumstances, were in disfavor with many surgeons. Some idea of this dissatisfaction may be obtained from the report of the Ninth Congress of the French Urological Association (1905). At this meeting the majority of the surgeons spoke very conservatively concerning their operative results. Malherbe recommended early operation for papilloma, but was opposed to operations for carcinomata. Pousson had most unfavorable results in malignant growths, and Legueu, on account of the frequency of recurrences, was only in favor of extensive resections. Eschat, while in favor of early operation for benign tumors, was decidedly against operative procedures for malignant tumors, and the same stand was taken by Desnos. Motz was in favor of total extirpation of the bladder even in relatively small tumors if they were infiltrating. Hamonic was in favor of an early removal of benign and malignant tumors that were favorably located, but was opposed to operating on diffuse malignant tumors. He also was opposed to total extirpation. Albarran reported 20 cases of benign tumors, with favorable results; 6 of these remained free of recurrence thirteen or fourteen years. In 26 carcinomata 1 case remained free twelve and a half years and 6 others were free of recurrence from one to six years. When the tumors are small but infiltrating, according to Albarran, an extensive resection should be carried out, while tumors involving the region of the prostate should not be operated upon. In the Parisian Société de Chirurgie (February, 1909) the majority argued against operation in bladder carcinoma. In 1910 Cathelin reported 32 cases of bladder carcinoma operated upon by him, and spoke most unfavorably of operative results. He emphasized the great frequency of malignant recurrences after the removal of benign papillomata, and states that patients with carcinoma of the bladder live longer without operation, a view which had already been expressed by Casper and others. It is obvious that most of the authors are in agreement concerning the advisability of operation in benign tumors

and against operation in malignant growths. The opposite view is maintained by Zorppfie, who maintains the opinion of many reputable Russian surgeons that benign tumors of the bladder should be let alone and only carcinoma subjected to operation. At the Second Congress of the German Association of Urology in Berlin (1909) the consensus of opinion was that all tumors of the bladder should be radically removed. The various authors differed as to whether the suprapubic or endovesical method was preferable. From a study of the situation and the results obtained by various operative procedures, Esydon concluded that total extirpation of the bladder should be performed in every case in which the tumors were multiple or in which malignant infiltration had occurred, and that only when the tumor was single and definitely pedunculated was a less radical procedure advisable.

The exceptionally brilliant results obtained by the high-frequency current have radically changed the views of surgeons concerning the treatment of vesical tumors, and have considerably clarified the situation. It is now definitely settled that the endovesical method (fulguration or radium) is the treatment of choice for all papillomata, single or multiple, benign or malignant, and that suprapubic attack is only justifiable in exceptional cases. It has been conclusively demonstrated that fulguration fails when the growth is infiltrating and radical operative procedures should be employed. Occasionally, owing to cystitis, contracted bladder, stone or other complications, rendering instrumentation extremely difficult or impossible, suprapubic excision of the tumor will be necessary and fulguration utilized to treat recurrences should they develop.

Technic.—When suprapubic cystotomy and excision of the tumor are employed extreme care should be taken to prevent implantation of the tumor on the bladder mucosa and along the suprapubic tract. Implantation of the bladder tumor in the suprapubic scar has occurred in 5 of our operative cases.

A catheter should be passed and the bladder emptied and thoroughly irrigated with a sterile solution. Following this it should be distended with air rather than fluid. If fluid be used the possible escape of tumor particles in the wound area, following the opening of the bladder, greatly increases the danger of implantations. If possible the location of the tumor should be determined by cystoscopic examination and care taken to avoid opening the bladder through the tumor. Every precaution should be used to protect the wound, and some surgeons recommend suturing the edges of the bladder to the skin until the operative procedures in the bladder have been completed. This technic we do not consider necessary. A suction pump connected with a tube placed on the base of the bladder will assist in keeping the field clean and render frequent sponging unnecessary. Sponges dipped in alcohol should be used in preference to dry gauze sponges. Great care should be exercised in the use of retractors and trauma to the

tumor should be avoided, as particles are easily detached and the danger of implantation thereby increased. After the tumor is properly exposed, the greatest care having been exercised to avoid touching or handling, it should be thoroughly burned with actual cautery. The operator can now palpate the base of the tumor and determine if it is freely movable or attached and infiltrating. If the base is freely movable on the underlying mucosa the galvanocautery or Paquelin cautery may be used to excise the pedicle with the surrounding area of mucous membrane and the shrivelled and burned tumor removed carefully so as not to touch the bladder wall or suprapubic wound. If feasible the edges of the mucous membrane of the bladder can be brought together with a continuous suture of catgut. By this means healing may be facilitated and hemorrhage controlled. After removal of the tumor the bladder should be closed snugly around a rubber tube.

When the tumors are multiple more difficulty will be encountered in avoiding trauma to them and the dangers of recurrence will be correspondingly increased.

It seems not improbable that some of the unsatisfactory results following suprapubic excision of pedunculated bladder tumors have been caused by insufficient appreciation of the danger of implantation, and undoubtedly a more careful technic in many of the cases operated upon would probably have prevented some of the disastrous results obtained. When the tumor or tumors are pedunculated and non-infiltrating, and the base of the tumor is freely movable upon the underlying muscularis, excision by the method outlined above removes the tumor just as radically as resection. No matter how careful the technic or what method of operation is employed, recurrences will follow in a certain percentage of cases. Recurrences are less frequent following fulguration than when operative procedures are employed for removal of the tumor, because the dangers of implantation are less. It should be noted that recurrences following fulguration are usually single, but following operation frequently are multiple.

Resection.—Experience has shown that when the growth has infiltrated the bladder wall, resection of the tumor-bearing area through all the coats of the bladder, with as wide a margin of healthy tissue as seems advisable, is the only method which offers much hope of success. Resection is indicated when the tumor is of such a size that it can be removed completely, even though this necessitates the transplantation of the ureter. It is quite generally conceded that resection should not be undertaken when the tumor has infiltrated close to the vesical orifice, and particularly when it has invaded the prostate. We have seen, however, one interesting case of a large carcinoma of the anterior bladder wall with invasion of the vesical orifice in which complete removal was possible because of an associated prostatic hypertrophy. As shown in Fig. 90 the cancer with a wide margin of bladder wall was removed *en masse* with the internal sphincter and the

hypertrophied lobes. It is also questionable whether resection should be performed when the tumor is so extensive that it will require transplantation of both ureters. When the tumors are multiple, resection again is contra-indicated unless the tumors occupy an area which will allow their removal in one piece or at most two. Tumors occurring on the anterior bladder wall are the most favorable for resection.

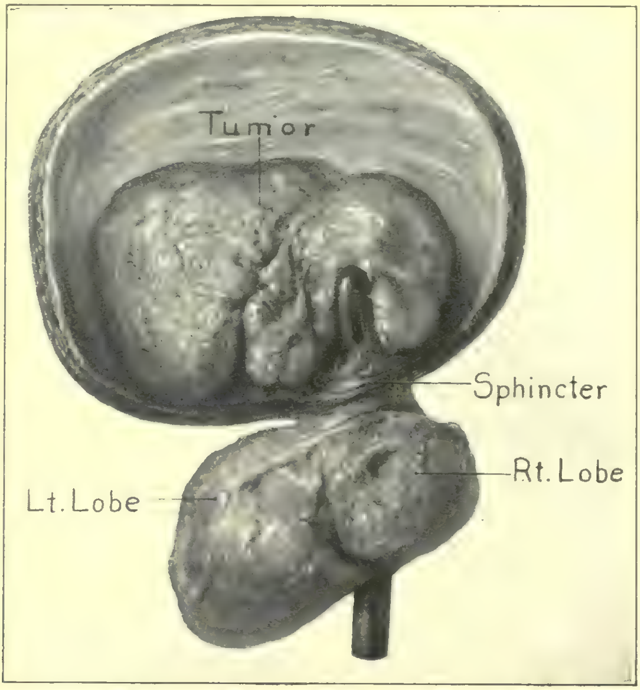

FIG. 90.—Operative specimen showing removal in one piece of large part of anterior wall of bladder, vesical orifice and sphincter, and good-sized hypertrophied prostate. The cancer involved the lower surface of the vesical orifice. Patient living and well one year after operation.

Technic.—The same care to avoid implantation of the tumor should be carried out in doing resection as was indicated above. The technic of the operation will vary with the position of the tumor. When the tumor lies on the anterior bladder wall a special technic is recommended by Hagner as follows: The cystoscope is introduced into the bladder through the urethra. The bladder is then exposed suprapubically and the tumor-bearing area mapped out with needles, the cystoscopist indicating where the needles should be inserted. This technic enables one to remove the tumor-bearing area with the least danger of trauma to the tumor. This procedure, however, is only feasible when the tumor is on the anterior wall.

When transplantation of the ureter is to be carried out, as the

previous examination has determined, the procedure suggested by Squier seems preferable. Before opening the bladder it is freed on the side on which the resection is to be done. The ureter is located before the bladder is opened, and by palpation of the bladder wall the limits of the growth are mapped out as accurately as possible. After the ureter is freed a tape is passed about it, so that when subsequently the bladder is opened and the tumor-bearing mass excised it will facilitate the finding of the ureter. When the ureter is not located before it has been divided it may be extremely difficult to find the cut end for subsequent implantation. In excising the bladder wall some surgeons prefer the cautery. Others the knife or scissors. When the knife or scissors is employed, unquestionably the wound edge stands a better chance of healing *per primam* when subsequently sutured than if the cautery has been employed. If a wide margin of healthy mucous membrane is provided on all sides of the tumor the dangers of implantation should not be increased by the use of the knife or scissors. The defect in the bladder wall is repaired by continuous catgut suture, including the serous, muscle, and mucous layers. We have found it advisable to employ chromic catgut for the suture. Drainage should be employed, a large rubber tube being sutured into the anterior wall of the bladder.

Some surgeons prefer to attack the bladder for resection transperitoneally. We have found this advisable only when the tumor occupies the posterior wall of the bladder and not necessarily as a routine procedure. We have not found that it facilitates the operative procedure to any degree when the tumor occupies the lateral or posterior aspect of the bladder, and it seems to add an unnecessary risk to the operation. Where, however, a free exposure can be better obtained by opening the peritoneum this method should be employed without hesitation. After the peritoneum has been opened it should be subsequently repaired and only exceptionally should the peritoneal cavity be drained. Certain advantages of the transperitoneal route have been claimed by its advocates, namely, the possibility of determining the presence of metastases in the retroperitoneal glands or abdominal viscera, which would render useless an extensive radical procedure. When the presence of metastases can be determined or when the growth has extended through the bladder wall, involving the adjoining structures, radical excision should not be carried out.

Transplantation of Ureter.—We have found it more satisfactory not to implant the ureter in the line of incision of the resection but to make a separate opening in the bladder wall by means of a clamp or knife and draw the cut end of the ureter through this new opening at a point on the bladder wall which will not put tension on the ureter. The ureter stump is allowed to project into the bladder about one-quarter inch and stay sutures of catgut are introduced to hold it in position, the suture including the bladder wall and the ureter. Usually four sutures of catgut are employed.

The ureteral stump may be treated according to the method suggested by Mayo. The ureter is implanted in the manner indicated above and, in addition, the free end in the bladder is split at two points so as to increase the size and keep the opening patent. The advocates of this procedure claim that the possibility of stricture formation is lessened by its use.

Complete Extirpation of the Bladder.—The most radical method of treating bladder tumors is by complete extirpation of the bladder. This operation was first introduced by Bardenheuer in 1887, and while technically relatively simple it has not met with general favor on account of the pitiable condition in which it usually leaves the patient. Since Bardenheuer described his technic until the present time, most modifications of the operation have related to the treatment of the ureter. The ureter was formerly abandoned in the operative field, no attempt at transplantation being made. Drains were carried down to the free end of the ureters, and in this way a permanent urinary fistula, opening upon the surface, in the region of the operative wound, was established. The frequent stricture of the ureters, due to inclusion in the operative scar, with resultant hydronephrosis, has thrown this procedure into disfavor, and it has long since been abandoned. The ureter has been transplanted into the rectum, vagina, and in some cases it has been sutured into the abdominal wall. None of extravesical methods is entirely satisfactory, for in addition to the extreme discomfort to the patient following their employment, ascending renal infection is not infrequent.

Watson recommends that previous to cystectomy a double nephrostomy be performed and the ureters ligated just below the ureteropelvic junction. He considers that the subsequent damage to the kidney will be less from nephrostomy than that resulting from possible obstruction following ureteral transplantation.

It is now almost universally conceded that the operation should be done in two stages. At the first operation the ureters are exposed, the lower end divided close to the bladder, the upper end brought out in front of the abdomen and sutured to the skin, small catheters being placed in the ureteral openings. Bringing the ureters out in front of the abdomen is to be preferred because it enables the patient subsequently to take care of himself to better advantage.

The second operation which consists in the removal of the bladder should not be performed until the patient has completely recovered from the first operation and the renal condition such that the second operation has a reasonable chance of successful outcome.

Technic of the Extirpation of the Bladder.—Expose the anterior surface of the bladder and strip off its peritoneal investment as far as possible. Draw down the bladder as this maneuver proceeds in order to make it more accessible. Continue until the ureters have been reached. These, it will be remembered, have already been tied off at their upper ends in the first operation if Watson's plan is carried out.

Apply a ligature with an aneurysm needle to each ureter as high up as can be done and divide them. Draw the bladder upward as far over the symphysis as possible, complete the removal of its peritoneal investment, and separate its surface and that of the prostate from their connection with the rectum posteriorly.

Lift the bladder well up with volsellum or other appropriate forceps, and with a curved needle held in the needle-holder pass a double ligature of No. 2 chromicized catgut through the median line of the posterior surface of the lowest part of the neck of the bladder, letting the needle emerge through the anterior wall at a corresponding point. Cut the ligature in two at the eye of the needle. Ligate the neck of the bladder in two halves, including each half in one part of the double ligature.

Divide the bladder by a transverse incision just above the ligatures and draw the organ out through the wound. Sponge the field of operation and dry and cleanse it.

Make a free counter-opening in the median line of the perineum and pass a gauze drain through it as far up as the peritoneum. Close the abdominal incision tight. (The steps of the operation are shown in Figs. 81, 82 and 83.)

If the prostate and seminal vesicles are involved they should also be removed. In this case the vasa deferentia must be ligated, preferably near the inguinal ring, divided and removed with the bladder.

The prostate can be removed with the bladder by ligating the urethra below the apex of the prostate in a manner similar to that described in the case of the vesical neck.

A study of the results of this very radical operation prove that a cure in the event of a successful outcome of the operation, plus freedom from recurrences, has only been obtained in 5 per cent. of the cases. This brings up the question whether it is advisable to subject patients to such an extensive operation when as uccessful result is so rarely obtained. On the other hand, it should be emphasized that after cystectomy some of the patients have remained cured as long as fifteen years (Pawlik), and that without operation, death is inevitable. The question of extirpation should at least be explained and submitted to the patient himself for decision.

Palliative Treatment.—If the carcinomatous growth is too extensive or the physical condition of the patient such that radical operation is contra-indicated, palliative treatment may be adopted. Pain and hematuria are the symptoms most frequently met with, and various measures may be employed for their correction. If the suffering of the patient is extreme because of the acid urine coursing over the ulcerated bladder, treatment designed to divert the stream of urine, either by double nephrostomy or permanent suprapubic fistula, may be required. In some cases the hemorrhage may be combated and the life of the patient prolonged by high-frequency applications. If the growth is sufficiently extensive about the vesical orifice as to cause

marked obstructive symptoms, fulguration by means of Young's sound or the deep cauterization of the entire neck by actual cautery after suprapubic exposure may be necessary.

In certain cases it may be impossible either by means of suprapubic or perineal drainage to obtain relief from the intolerable urinary symptoms, and occasionally it will be found advisable to do a double nephrostomy, tying the ureters off, or bringing them out on the abdomen so that the irritable and ulcerated bladder can be put at rest.

The experience in our clinic in recent years indicates clearly that benign and malignant papillomata should be treated by fulguration; excision or resection should not be practised except when intravesical treatment is impossible or very difficult. Radium has been a great aid in the treatment, particularly of the malignant papillomata, and our best results have been obtained when the radium was placed directly against the tumor. When the tumor is a papillary carcinoma, resection should be practised by a technic which will reduce to a minimum the dangers of implantation or recurrence. Radium as yet has not given us results in this type of tumor sufficiently encouraging to warrant our employment of it in preference to resection in cases which are considered operable. Following resection, cystoscopy should be performed at an early date, and at frequent intervals, especially for the first year, and if recurrences are noted, they can occasionally be successfully treated by a combination of fulguration and radium. Unfortunately, as already stated, a large percentage of cases are first seen with the disease so extensive that nothing more than palliative measures can be adopted.

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SECTION II.

THE URETER.

CHAPTER VIII.

ANATOMY, ABNORMALITIES, INJURIES AND DISEASES OF THE URETER.

By GUY L. HUNNER, M.D.

EMBRYOLOGY.

A STUDY of the diseases of the ureter should begin with a brief review of the embryological development of this organ. Until quite recently the discovery of anomalous ureters was considered of anatomical interest only, but with the development of the surgery of the urinary tract so many errors in diagnosis and treatment have occurred

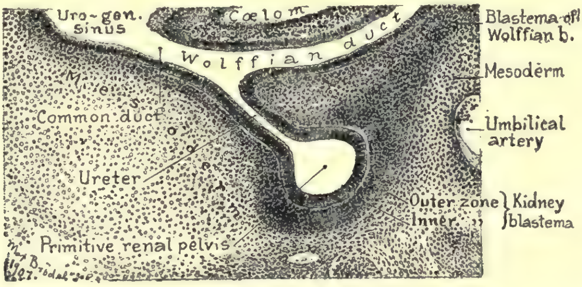


FIG. 91.—Sagittal section through lower end of 5 mm. human embryo, showing kidney bud. (After Kelly-Burnam.)

because of a lack of appreciation of the possibilities in anomalous conditions of kidneys and ureters that a knowledge of their embryological development and malformations is now considered essential.

Reference to Figs. 91 and 92 recalls the normal embryological arrangement of the primordial kidney and ureter, while a study of

Figs. 93, 94, 95, 96 and 97, together with their legends assists one to an understanding of many of the anomalies of kidney pelvis and ureter. These diagrams show the origin of divided renal pelves to be due to the precocious division of the ureter anlage. They also show the division of the ureter at various levels between the kidney and bladder,

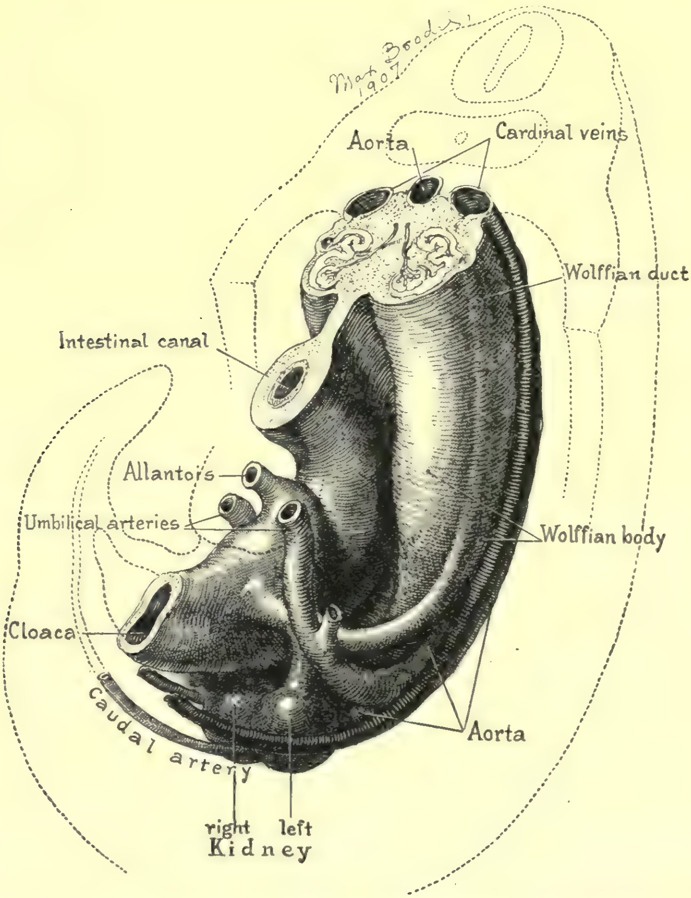
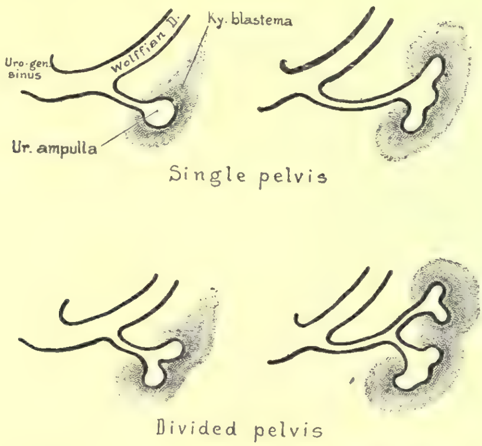


FIG. 92.—Reconstruction of the Wolffian body, human embryo of about four weeks. (× 40.) (After Kelly-Burnam.)

and the occurrence of double ureter on one or both sides. Fig. 96 shows the relations of the ureter anlagen to the Wolffian duct, and explains the crossing of the upper and lower ureters so that the upper kidney drains into the bladder through the lower orifice. If the upper ureter which remains with the Wolffian duct in its downward migration fails to detach from the Wolffian duct and connect with

the allantois or bladder, it may be carried on to appear in the urethra or in the seminal tract in the male, and in the female its orifice may open into the urethra or be carried down to open into the Müllerian



FIGS. 93 and 94.—Diagrams illustrating the origin of a divided renal pelvis as compared with that of a single pelvis. (After Kelly-Burnam.)

duct (Fallopian tube, uterus, or vagina). The vaginal opening may be at any point from the vaginal vault to the vulva (following the

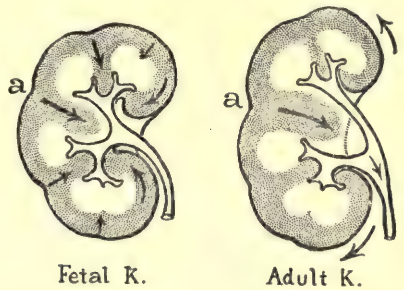


FIG. 95.—Division of renal pelvis into upper and lower branches. The division is caused by an especially deep column of cortical substances (*a*), which has forced its way almost to the hilum. After the kidney has unfolded itself, as shown in the figure to the right, the pelvis becomes an extrarenal organ, appearing at the hilum as a divided pelvis, thus simulating cases of precocious branching of the ureter during the embryonic stage. (After Kelly-Burnam.)

obliterated Wolffian or Gartner's duct). A single ureter may in the same manner cling to the descending Wolffian duct, and have its orifice established at any point along the urogenital tract.

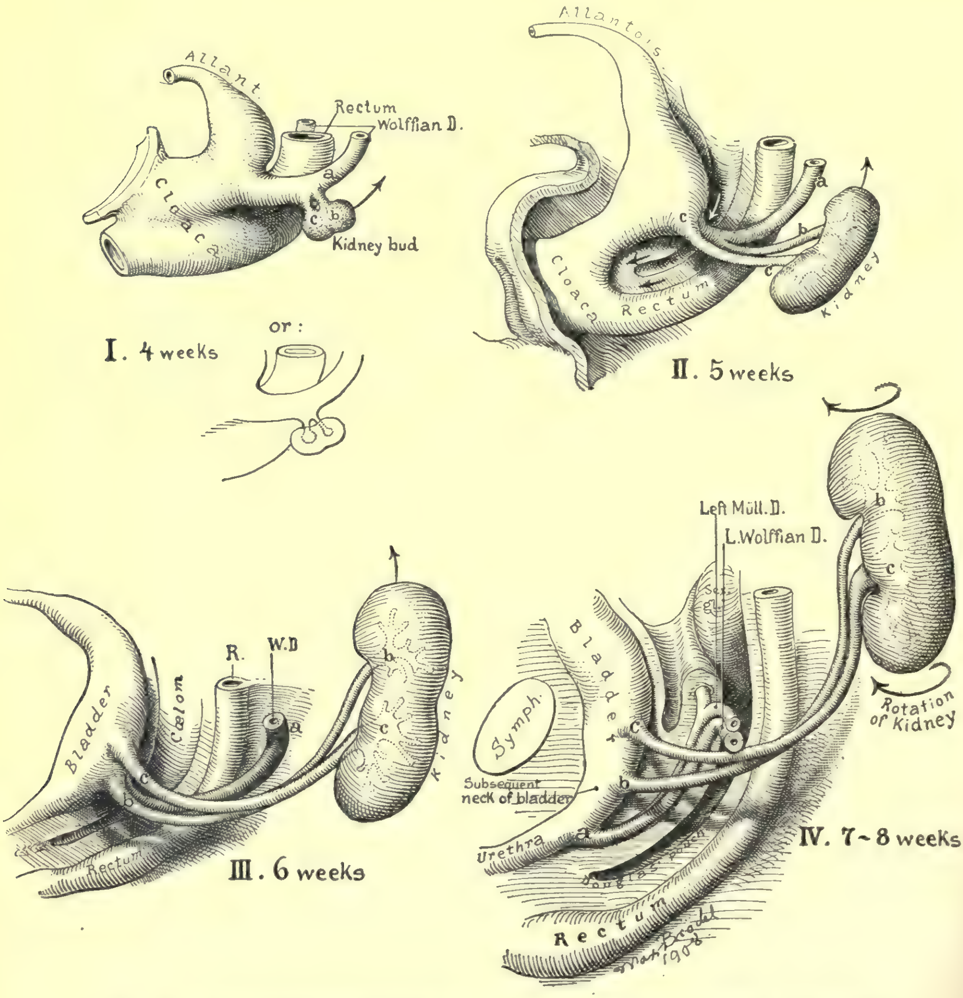


FIG. 96.—Four diagrams illustrating the development of a kidney with divided pelvis and double ureter. The figure shows why the ureters cross and why the upper pelvis and ureter drain into the lower vesical orifice, while the lower pelvis and ureter drain into the upper vesical orifice. *I.* The double ureter starts from the Wolffian duct either (*a*) as two separate anlagen (*b* and *c*) or as an original single anlage showing a precocious branching which resembles a double anlage. *II.* Through expansion of the lateral portion of the allantois, the lower Wolffian duct becomes dilated and the lower ureter (*c*) is the first to reach the allantois. The Wolffian duct (*a*), carrying the upper ureter (*b*) with it, shifts with the urogenital sinus in a downward direction, between the allantois and the rectum, as shown by arrows, until the second ureter (*b*) also becomes implanted in the bladder, but farther down and more mesially than the first (*c*). *III.* We here see a continuation of the same process of advance of the Wolffian duct with a greater separation of the duct from the ureter. *IV.* The Wolffian duct continues to travel downward with the advance of the urogenital sinus and finally becomes permanently lodged at the neck of the bladder (*a*) in the male; in the female it continues still farther down. This last picture represents the final arrangement, as seen in the adult. Note that the original order *a*, *b*, *c*, as shown in first picture, is now reversed to *c*, *b*, *a* at the bladder. (After Kelly-Burnam.)

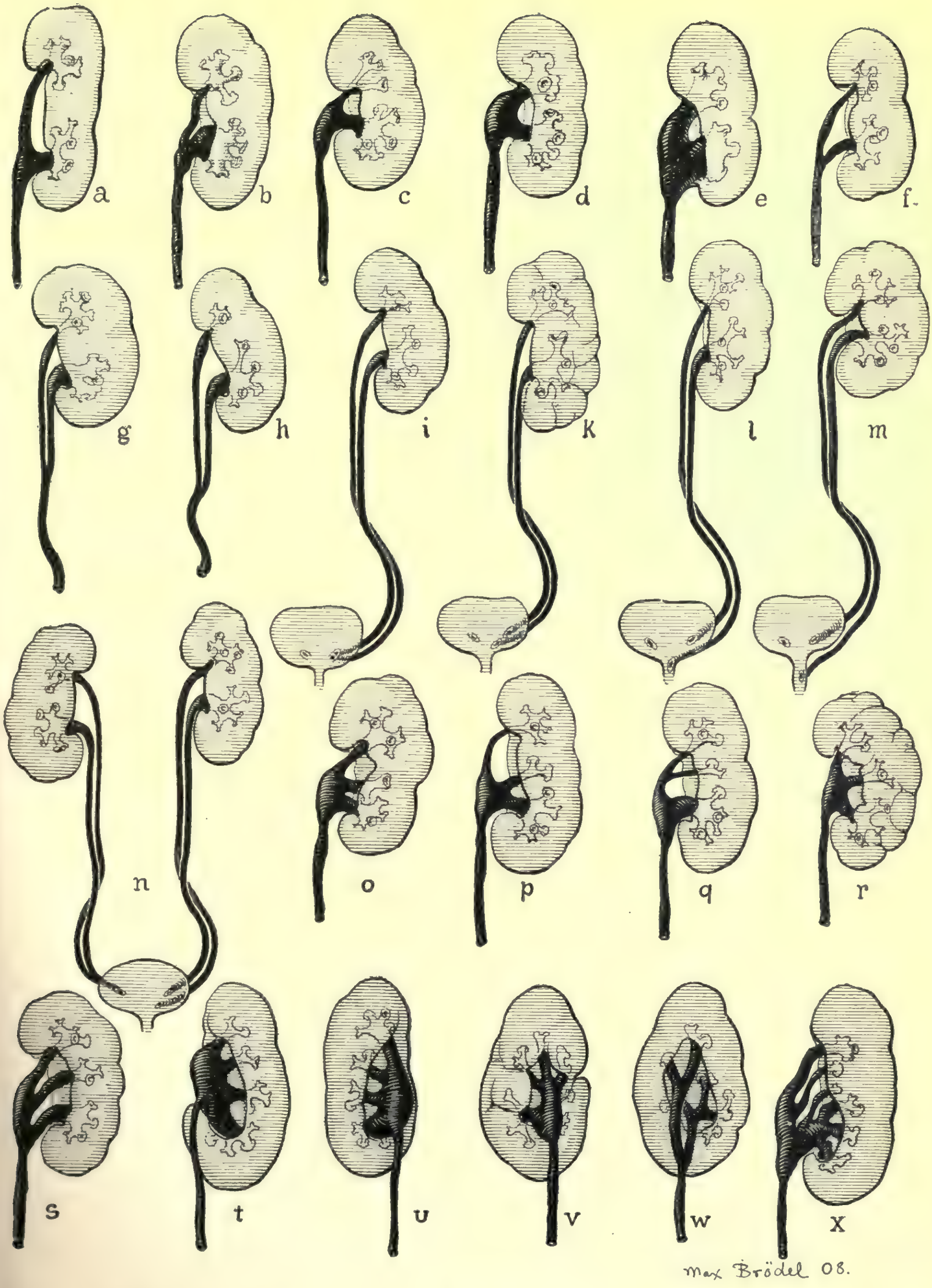


FIG. 97.—Diagrams from actual cases, showing anomalies of ureters and renal pelves. Above are cases where the ureter branches to form two separate pelves, just before entering the kidney. In the next row, the division takes place farther down, until both ureters are separate in their entire course; the vesical orifices are close together or farther apart, the lower one even reaching the urethra. In the third and fourth rows the ureter branches outside the hilum at the point of first division into two, three, four, five and even six separate calices, with or without the formation of a pelvis. (After Kelly-Burnam.)

Kelly and Burnam classify anomalous ureter terminations as follows:

I. In the male genito-urinary apparatus.
   1. In the bladder.
   2. In the urethra.
   3. In the seminal vesicle, vas deferens, and ductus ejaculatorius.

II. In the female genito-urinary apparatus.
   1. In the urethra.
   2. In the vagina.
   3. In the vestibule of the vagina.
   4. In Gartner's canal.
   5. In the uterus or tubes.

III. In the bowel.
   1. In the rectum and cloaca.
   2. In the intestines.
   3. In the urachus and amniotic cavity.

IV. In case of congenital absence of the bladder.
   1. In the urethra.
   2. In the vestibule of the vagina.

V. Blind endings.

Surgery of the Ectopic Ureter.—In case of ectopic ureteral orifice, one is guided surgically by the conditions present in the individual case. Cases opening into the urethra and presenting incontinence, and all cases opening into the vagina or about the vulva are of the utmost practical importance. They present the characteristic symptom of incontinence dating from infancy, together with the normally periodic voiding of urine.

With our modern methods of catheterization, functional, chemical, and microscopic tests, and roentgenography we should be able to determine how many ureters are present, their courses from kidney to exit, and the value of the kidney substance drained by each ureter.

Equipped with such data we can decide whether operation is indicated and whether it should be the radical extirpation of a kidney or of a diseased half-kidney, or whether we should attempt to divert the abnormally placed channel into the bladder. By roentgenography we can determine the size and position of the abnormal ureter, and be better equipped for deciding on the best method for connecting this with the bladder.

We have the choice in different cases:

1. That of diverting the urine to the bladder without a cutting operation. This was done by the author in a case illustrated in Fig. 98.

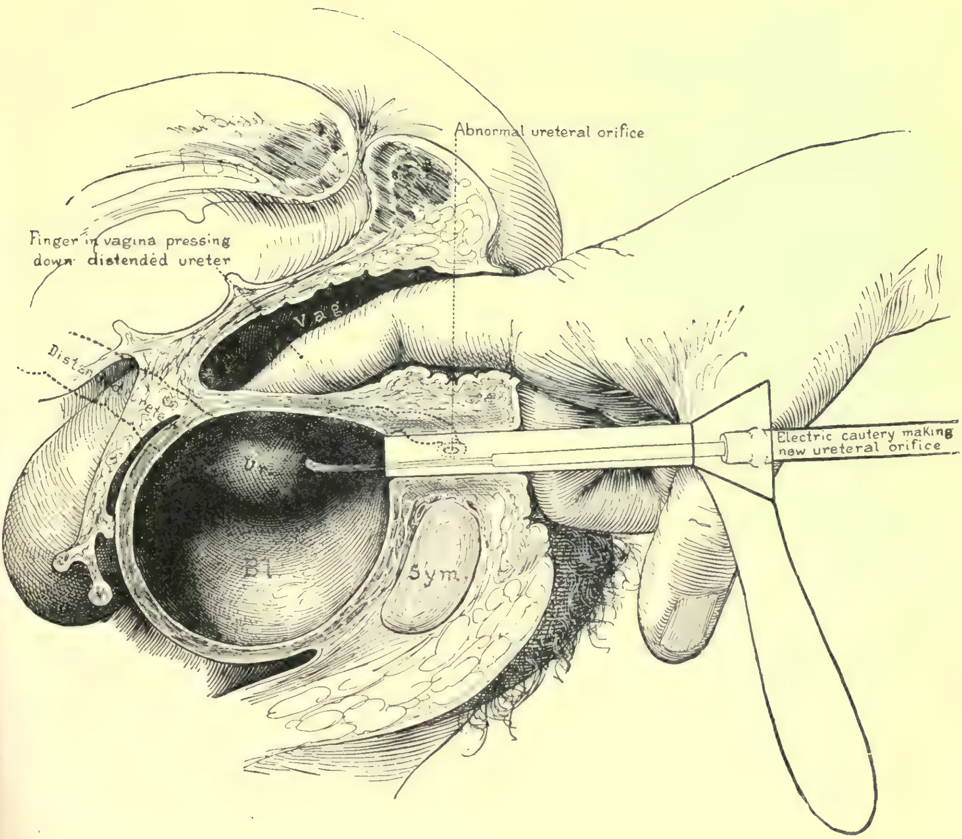


FIG. 98.—Sagittal view of method for treating dilated anomalous ureter opening into urethra. The illustration should show a renal catheter in the misplaced right ureter. Over the end of the catheter was fastened a thin rubber-glove finger. After its introduction through a No. 10 Kelly speculum to the lower end of the ureter this glove finger was inflated with air pumped through the catheter. The inflation caused a marked prominence in the thin-walled vagina, but no recognizable prominence in the thicker walled bladder base, until by finger pressure in the vagina the bladder prominence was brought out as illustrated. The cautery blade burned through the vesico-ureteral tissues to a depth of from 0.5 to 1 cm. before collapsing the pneumatic bag and establishing the ureterovesical opening. The only anesthetic used was a hypodermic of morphin and a local application of 20 per cent. cocain to the bladder base. The opening was probed from time to time until the patient went home one month after the operation. Eighteen months later the patient's physician reported that she had been entirely free from symptoms. This patient, aged fifty-six years, had never had incontinence, and was admitted to the Johns Hopkins Hospital in February, 1907, complaining of symptoms simulating stone in the ureter, the attacks having been of only seven weeks' duration. Investigation revealed a dilated right ureter and kidney pelvis holding 165 c.c. The ureter opened on the right posterior urethral wall, 1 cm. exterior to the sphincter urethræ, and apparently possessed sphincteric action. The bladder urine from the left kidney was normal, specific gravity 1008, faintly acid; urea 1 gram to the liter. The urine from the dilated ureter was turbid, with many epithelial cells, of the transitional forms, and many small mononuclear cells of the size of leukocytes. Cultures were negative; specific gravity 1007, faintly alkaline; urea $\frac{1}{4}$ gram to the liter. (From Kelly-Burnam.)

A similar method was used by Bois who introduced a tenotome in the misplaced ureter, and, with a grooved catheter in the bladder to cut down upon, he incised the ureterovesical wall and kept open the fistula thus established by passing an olive-pointed sound through it daily for a week.

Schwarz[38] reports a case operated by Wölfler by the use of a compression clamp, one blade of which was placed in the bladder and the other in the abnormal ureter, the opening being established by the sloughing of the intervening bladder and ureter walls.

2. We may confine the operation to the vaginal route, particularly if the abnormal ureter opens low in the vagina or about the vulva.

The procedure may consist in dissecting out the distal end of the ureter and carrying this into the bladder, as reported by W. H. Baker,[1] by Davenport,[10] by W. H. Maxon,[26] and by Furniss.[17]

Colzi varied but complicated the method of vaginal approach by making an inverted T-incision over the symphysis at the vestibule and getting at the base of the bladder and the abnormal ureter by chiselling off the lower edge of the symphysis and depressing the urethra and anterior vaginal wall.

Burnam[25] successfully operated on 2 cases in each of which the supernumerary ureter was a widely dilated canal running between the bladder wall and vagina and emptying into the urethra. "The ureter was opened longitudinally through the vaginal wall. Then an opening, also in a longitudinal direction, was made between the ureter and the bladder, the mucous membranes being carefully stitched around the opening. The opening on the vaginal side and the severed end toward the urethra were carefully closed, and, finally, the vaginal wall."

3. We have the choice of the abdominal extraperitoneal route approaching the bladder and ureter either through a midline or a lateral incision. Tauffer and Velits report the case of a fourteen-year-old girl who had suffered a constant dribbling of urine since birth. Investigation showed two normal ureters entering the bladder and a third ureter on the left side entering the posterior wall of the urethra. After entering the bladder by the suprapubic route a sound was passed up the supernumerary ureter, its knobbed end was pressed against the bladder wall at the level of the normal left ureter orifice, and an incision was made upon the sound. The mucosa edges of the bladder and ureter were joined by sutures and the distal end of the ureter was destroyed by the cautery.

Baumm performed a similar but more complicated operation by the same route, using silk sutures which were the probable cause of formation of a urinary concretion some months later.

Albarran, by the same route, first isolated the supernumerary ureter from the vagina, and after cutting off its distal end he implanted the ureter into the posterior wall of the bladder.

ANATOMY OF THE URETER.[1]

The ureter is a fibromuscular organ lined with mucous membrane, and having, so far as we know, but one physiological function, that of conveying the urine from the pelvis of the kidney to the bladder. It has an average length of from 28 to 30 cm., being slightly longer on the left than on the right and longer in men than in women.

Its outer diameter averages 4 to 5 mm., the normal lumen varying in diameter from 1 to 2 mm. Fig. 99 illustrates in an accentuated manner the various normal points of narrowing, with the long spindle-shape dilatations lying between these constricted areas.

Histologically, the ureter resembles the bladder in having three coats (Fig. 100): an outer sheath of loosely constructed fibrous tissue, in which run the major vessels, and a middle coat composed of three layers of involuntary muscle fibers, the outer and inner longitudinal layers, and the middle layer of better developed circular fibers. The third coat of the ureter or mucosa consists of two layers, the tunica propria or submucosa, composed chiefly of strong fibro-elastic tissue, and the inner layer of stratified transitional epithelium.

It is of practical importance to realize that the epithelial layers of kidney, ureter, and bladder are continuous and of similar composition, and that it is impossible in an examination of the urine to designate from which of these three organs the cells in the urine are derived.

We still have patients bring written urinary analyses from laboratories where this differentiation is attempted, and it inevitably casts suspicion on the value of the entire report.

Arteries of the Ureter.—Fig. 101 together with its legend, is so complete that a detailed description of the main supply vessels is not required in this text. "In the loose fibrous outer coat of the ureter the arteries form a plexus, consisting of longitudinal tortuous branches, from which at short intervals many smaller tributaries arise, anastomosing freely and penetrating the muscle coats of the ureter in many places. The arrangement is such that periodical contraction and distention of the canal do not injure its delicate blood supply. Having reached the submucosa, they form another more delicate plexus whose meshes are elongated in an up-and-down direction. From these delicate arteries the capillaries take their origin, those to the epithelium passing inward, while the muscle capillaries run outward."

It is of practical importance to note that a characteristic of the ureteral arteries is their free and broad anastomosis, which makes it possible to inject the entire system through any one of the supply branches.

[1] The author wishes to thank Drs. Kelly and Burnam and their publishers, the Messrs. D. Appleton and Company, for the many illustiations generously loaned from their monumental work on "Diseases of the Kidneys, Ureters, and Bladder." Most of the conclusions here expressed on the embryology and anatomy of the ureter are taken from this work because of a belief in their soundness, based as they are on the scientific, painstaking, and accurate work of Mr. Max Brödel.

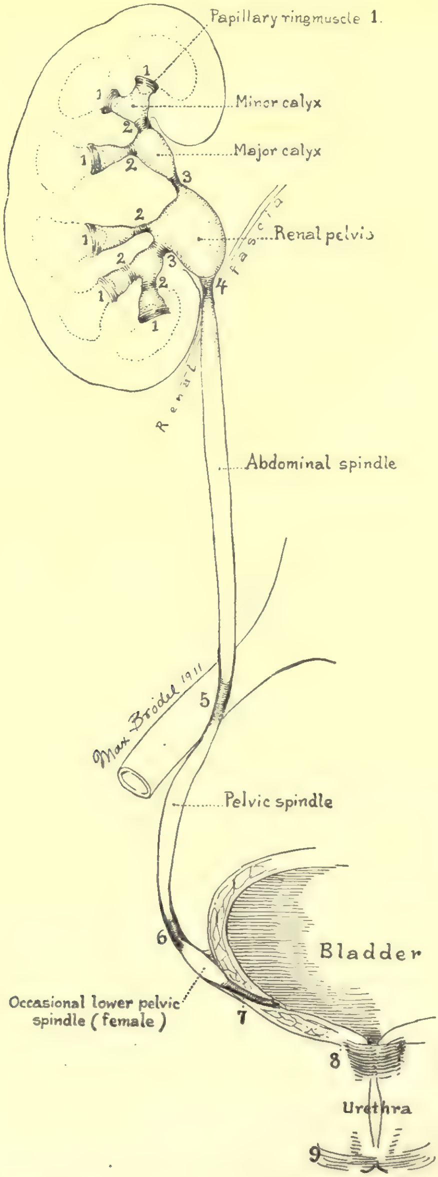


FIG. 99.—Diagram of the urinary tract in women, showing a series of well-defined compartments separated from one another by little ring muscles which represent thickenings of the circular coat in these places. The condition has been shown considerably accentuated in order to illustrate the point. The first ring muscle (*1*) is seen encircling the papillæ; the second (*2*) at the neck of the minor calices; the third (*3*) at the neck of the major calices; the fourth (*4*) between pelvis and ureter; the fifth (*5*) at the crossing of the iliac vessels; the sixth (*6*) in the broad ligament; the seventh (*7*) in the wall of the bladder; the eighth (*8*) at the internal sphincter; the ninth (*9*) at the external urethral orifice. This is no ring muscle, although there is a narrowing of the lumen at the meatus. As the diagram shows, the ureter has several spindle-shaped dilatations between these ring muscles. The most marked constriction is found at *4*; its narrowness is accentuated by the renal fascia passing over the ureteropelvic junction, as shown. (After Kelly-Burnam.)

It is also important for the surgeon to note that these same arteries help supply the peritoneum, the subperitoneal tissue, and the surrounding fat.

"The veins form a plexus in the submucosa which drains outward into the main trunks enveloped in the fibrous framework of the adventitia. These large ureteral veins are seen to anastomose freely with one another in the periureteral tissue and also with neighboring veins, such as the spermatic, or ovarian, the lumbar, renal, and, in the pelvis, with the uterine, vaginal, and vesical venous plexuses."

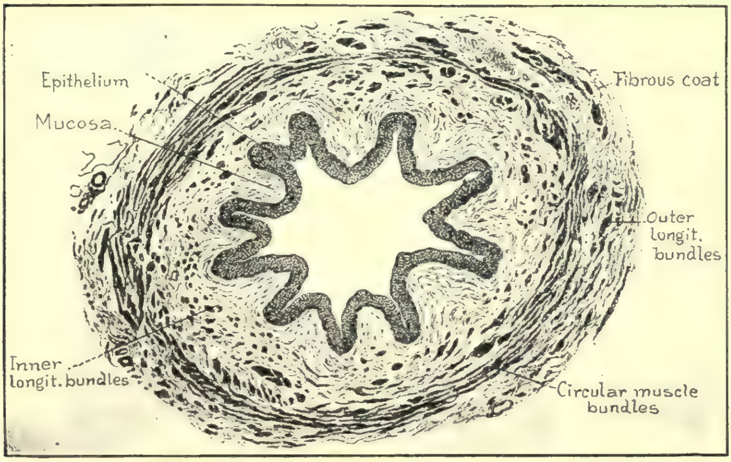


FIG. 100.—Transverse section of ureter showing the various coats, × 20. (After Piersol, Human Anatomy, 1907.)

Lymphatics.—"The lymphatics of the ureter are more numerous in the muscle coats and adventitia than in the mucosa and submucosa. They are seen to accompany the arteries and drain in three directions, the lower portion downward in the direction of the bladder, the pelvic and abdominal portion mesially into the pelvic and lumbar lymph glands, the upper portion in the direction of the renal lymphatics."

Nerves.—"The nerves come from the sympathetic nervous system, being derived from the renal, inferior mesenteric, spermatic (ovarian), and hypogastric (vesical) plexuses. They form a delicate network around the ureter with microscopic ganglia at the upper and lower ends, the end twigs being mostly distributed in the muscular coats, although some fibers can be traced to the epithelium. According to Waldeyer there are a few medullated fibers which can be demonstrated among the non-medullated ones."

Anatomical Relations of the Ureter.—There are a few anatomical landmarks to bear in mind in seeking to locate the ureter while operating from different avenues of approach.

When one is operating through a lumbar extraperitoneal incision and seeking the abdominal portion of the ureter it saves time, as a rule, to go directly to the pelvis of the kidney and trace the ureter down from its beginning. While the abdominal ureter is not as intimately incorporated with the peritoneum as is the pelvic portion, yet it generally rides away from the psoas muscle with the posterior peritoneum, as this organ is pushed forward in the search for the ureter.

In tuberculosis of the ureter and in cases of stone with marked periureteritis the firmer attachment may be to the psoas muscle, thus allowing the peritoneum to be more easily brushed from the ureter, leaving the ureter with the psoas fascia.

In a normal case the ovarian or the spermatic vessels may be a valuable guide, as they also run in the peritoneum, and in general cross the abdominal ureter at its middle portion, the vessels lying to the median side of the upper half of the abdominal ureter and to the outer side of the lower half. The locating of these vessels is of value, chiefly as an indicator that one is working near the ureter, for the relationship between ureter and vessels is rather variable.

Since most stones and most strictures of the ureter are located in its pelvic portion, we are most interested in the landmarks helping to locate the pelvic ureter.

For most ureter lesions the extraperitoneal route is the one of choice. As to the form of incision for exposing the extraperitoneal region there is much difference of opinion. Some surgeons still use the old direct incision through all the muscles and fascia, and almost "quarter" their patient. While it is a good principle in any operation to secure an abundance of room for easy work, I find this requirement fulfilled in women by using the gridiron incision and varying its position according to the portion of ureter to be attacked.

For deep pelvic work in the vesical region the deep field is brought

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EXPLANATION OF FIG. 101.

Fig. 101.—Arterial circulation of the ureter, × ½. *I*, front view of the urinary tract, the bladder drawn downward and forward in order to expose both ureters down to their vesical orifices. The upper ureteral arteries are derived from the renal arteries. (See also *II* and *III*.) The next branches come from the ovarian arteries and supply the abdominal spindle. Farther down a ureteral branch arises from the aorta at its bifurcation. This branch is subject to many variations; it may arise higher up or there may be two separate arteries coming from the aorta or common iliac. The next branches below, supplying the pelvic spindle, are derived from the internal iliac or one of its divisions. Farther down small tributaries are seen coming from the uterine, vaginal, and middle vesical, occasionally from the inferior vesical arteries. Most of these ureteral branches give off little twigs to the surrounding fat and peritoneum. In the outer coat the ureteral branches form a plexus, the larger vessels of which are very tortuous. These run parallel with the long axis of the ureter and anastomose freely, making it possible to inject the entire ureter from any of its arteries. *IV* shows the arterial circulation of the ureter seen from the mucous surface, five times magnified. *V* represents the arterial circulation of the renal pelvis seen from within, three times magnified. *VI* is a transverse section of the ureter showing the relation of the vascularization to the individual coats, twice natural size. (After Kelly-Burnam.)

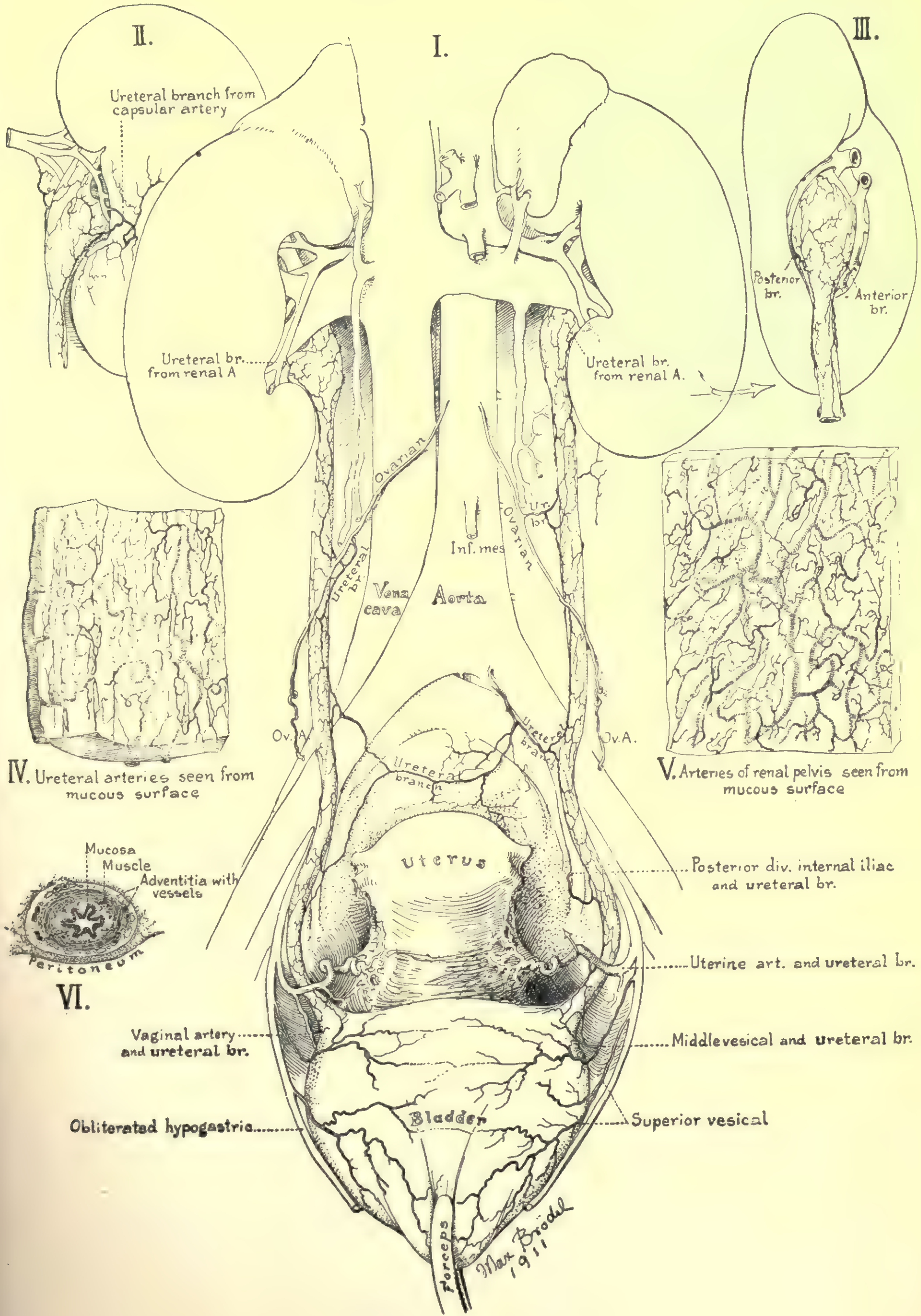
II.
I.
III.
Ureteral branch from capsular artery
Ureteral br. from renal A
Ureteral br. from renal A.
Posterior br.
Anterior br.
Ovarian
Ovarian
Ur. br.
Inf. mes
Ureteral br.
Vena cava
Aorta
Ov. A.
Ov. A.
Ureteral branch
Ureteral branch
IV. Ureteral arteries seen from mucous surface
V. Arteries of renal pelvis seen from mucous surface
Mucosa
Muscle
Adventitia with vessels
Peritoneum
VI.
Uterus
Posterior div. internal iliac and ureteral br.
Uterine art. and ureteral br.
Vaginal artery and ureteral br.
Middlevesical and ureteral br.
Obliterated hypogastric
Superior vesical
Bladder
Forceps
Max Brödel 1911

Fig. 101

nearer the incision and the intraperitoneal contents are kept out of the way by using the high elevated pelvis position of the table.

In cases of doubt as to which portion of the ureter will need investigation, I prefer the lateral semilunar line incision. This can begin at the level of the umbilicus and extend downward a hand's breath, thus exposing the ureter at the pelvic brim region. From this point the ureter can be traced by palpation upward to the kidney, and downward to the bladder. The incision can then be enlarged in either direction if necessary. The intercostal vessels and nerves crossing this incision may be saved by displacing and working between them. By beginning the incision at the umbilicus level and extending it downward a hand's breath one gains the advantage of reaching the peritoneum at a point above Douglas's semilunar line, where it can be detached from the anterior abdominal wall with ease. At and below Douglas's line it is sometimes awkward to separate the peritoneum unless the cleavage has been begun above this point.

If it is necessary to carry this semilunar line incision downward for work on the lowest portion of the ureter, one can usually stop where the deep epigastric vessels meet the edge of the rectus and thus preserve these vessels and the important musculofibrous structures about the conjoined tendon.

Having gained the extraperitoneal space by the incision of his choice, what landmarks has the surgeon to guide him to the pelvic ureter? If he has already palpated through the rectum or vagina a thickening of the ureter due to stone, stricture, or tuberculosis, he will probably push the deep peritoneum medianward and go at once for the ureter lesion, trusting the periureteritis to reveal to him the diseased area. It is usually of advantage to study the condition of the ureter above the lesion and in most cases one wishes to have a free ureter above the lesion; therefore, rather than plunge at once for the lesion in the depths of the pelvis, one systematically locates the ureter at the pelvic brim region and follows it downward to the lesion.

The structure most easily located in the extraperitoneal space of the pelvis is the external iliac artery skirting the brim of the true pelvis. This is traced back to the common iliac artery, where the common bifurcates into the external and internal iliacs. By keeping the thumb on the external iliac and allowing the index finger to swing under the vessel and gently slide along the pelvic wall the internal iliac is discovered as it branches downward from the common iliac. The ureter should be found in the peritoneum lying immediately over this point. Usually the ureter here takes on a small artery coming either from the common iliac or from the internal iliac or one of its primary branches.

Lifting the peritoneum with care at this region one is guided to the ureter by this small artery. If one is careless, or uses too much force in brushing the peritoneum medianward, this artery is torn, the oper-

ator is forced to stop and tie, and it becomes more difficult to locate the ureter because more peritoneum has been freed than is necessary.

The ovarian vessels are of some assistance in this region, for when located in the peritoneum one knows that the ureter is always farther medianward, and that the ovarians gradually approach the ureter at the pelvic brim region, but even at this point they are likely to be from 2 to 4 cm. distant from the ureter.

Except in conditions of severe periureteritis the ureter is easily lifted from the pelvic brim and is carried forward in the peritoneum. An exception to this rule occurs in case of a short supply artery in this region, when both ureter and peritoneum are held close to the pelvic brim until the artery is disposed of. In periureteritis affecting the pelvic brim region and particularly in tuberculosis of this region, the peritoneum may sometimes be separated from the ureter more easily than the ureter from the iliac vessels.

In the deep pelvis where we more often see severe periureteritis we often note that the cleavage is most easily found on the peritoneal side, but we occasionally meet cases in which the peritoneum is torn in the attempt to free it from the ureter.

In freeing a tuberculous ureter which is to be removed it is often of great advantage to split the thickened adventitia coat and to then peel out the remainder of the ureter tube.

Landmarks for Intraperitoneal Operations on the Ureter.—One seldom plans an intraperitoneal operation on the ureter, but the average abdominal surgeon has occasion to look for the ureter from within the peritoneum more often than from the extraperitoneal route.

The most useful and constant landmark whether one wishes to expose the abdominal or the pelvic ureter is the promontory of the sacrum. Locating this, one traces the bone to the side corresponding to the wished-for ureter. In the deepest portion of the groove beside the promontory of the sacrum, the ureter dips down over the pelvic brim. One can get at it as easily by palpating for the common iliac artery and where this bifurcates one finds the ureter dipping downward and forward along the inner side of the internal iliac artery.

If one has difficulty in seeing or feeling the ureter through the peritoneum at this point, as sometimes happens in patients with excessive fat, one can carefully nick the peritoneum at the pelvic brim and with blunt forceps enlarge the opening to a size of 2 or 3 cm. Through this opening one can pick up the peritoneum and easily palpate the flattened cord of ureter between the thumb and index finger. In case the ureter is more firmly attached to the retroperitoneal tissues, it is easily seen in this position after elevating the incised peritoneum. The worm-like peristaltic waves of the ureter are of great assistance in differentiating it from the neighboring vessels. These waves may be elicited by slightly pinching or tapping the ureter with a blunt instrument.

The ureter can now be traced either in its abdominal or pelvic

segment. If for any reason one wishes to open the peritoneum in following the ureter it should be cut whenever possible, at least 1 cm., from the ureter in order to best preserve the periureteral sheath and blood supply. In tracing the abdominal ureter it is well to remember that the ovarian vessels approach it rapidly above the pelvic brim and cross to its median side at about the middle of the abdominal

Fig. 102.—Uterus pulled forward against symphysis pubis. Peritoneum incised along the course of the ureters. (Kelly and Noble, Gynecology and Abdominal Surgery.)

segment. If one contemplates transperitoneal operation on the abdominal segment, it is better to make a generous incision through the lateral peritoneal fold of the colon, and, turning the colon medianward, to get at the ureter retroperitoneally. Through this route there is less danger to the mesenteric vessels, and the kidney pelvis is easily located and the ureter traced downward.

The most frequent and important occasion for locating the pelvic

portion of the ureter by the intraperitoneal route is furnished by operation for carcinoma of the cervix. In these cases one or both broad ligament regions are usually invaded by inflammatory reaction or metastases, or both, and it is of extreme importance to avoid injury to the ureter as it passes through this mass of abnormal tissue, as well

FIG. 103.—Uterus, ovaries, and tubes detached from their superior pelvic attachments. Index finger following the course of the ureter is thrust under the uterine artery and serves as a guide for the location of the uterine vessels close to the pelvic wall. (Kelly and Noble, Gynecology and Abdominal Surgery.)

as to clean out all of the tissues of the broad ligament so far as possible. To accomplish these two objects, it is safest to locate and isolate the ureter before proceeding to excise the broad ligament tissues.

This is best done as pictured by Clark in his illustrations (Figs. 102 and 103).

The ureter is located just before its penetration of the broad ligament by first picking up the uterosacral fold as it attaches to the posterolateral aspect of the uterocervical region. The ureter is discovered just outside of this fold running about parallel with it. It may be easier to locate the ureter at the pelvic brim as above described and to trace its course across the pelvis and so into the broad ligament. Having located the ureter, incise the peritoneum, and injure this structure as little as possible in order to preserve its circulation and to have peritoneum for protection of the ureter at the end of the operation. Tunnel under the uterine vessels with the finger or with long curved forceps and trace the ureter to its entrance into the bladder (Fig. 103).

For several years this finding and isolation of the broad ligament portion of the ureter was facilitated by the preoperative introduction of a small renal catheter, but it was found that the prolonged trauma thus induced to the ureterovesical region often resulted in a pyelitis. In every operation for carcinoma of the cervix there is great traumatism in separating the base of the bladder from the involved portion of the cervix and vagina, and the dangers of a postoperative cystitis and pyelitis are greatly enhanced by having one or two catheters opening the urethra to outside infection during the long operation.

INJURIES OF THE URETER.

Traumatic Injuries.—The human ureter, because of its length, elasticity, and protected position, is unusually free from ordinary traumatic accidents. Its length and tortuous route make it capable of considerable misplacement without injury, and its attachment at either end to a movable organ protects it from rupture except in those violent accidents which may result in rupture of either the kidney or bladder.

Fenger[13] says, in speaking of traumatic injuries to the ureter: "Early diagnosis in these cases is often difficult, if not impossible, because of the uncertainty of the symptoms. A slight transient hematuria which might be easily overlooked was noted in 3 cases. Hematuria may be entirely absent. If no injuries to other organs complicate ureteral rupture there are no grave symptoms in the beginning."

Today, with the use of a non-toxic, roentgenographic material like thorium, we should be able to demonstrate a leak in the ureter without danger to the patient. With a large whistle-tip catheter plugging the lower end of the ureter a quantity of thorium slightly more than sufficient to fill the pelvis of the kidney could be injected while taking the *x*-ray and a leak in the ureter located.

Gunshot and stab wounds of the ureter are rare. Morris[29] reports 5 cases from the literature. Under the section on Ureter Stricture I report a case of gunshot injury followed by stricture, the hydronephrosis symptoms beginning eight years after the injury (Fig. 118).

Surgical Injuries.—In marked contrast to this relative immunity from traumatic injury is the danger to the ureter from surgical injury. The anatomical relations of the ureter in the pelvis render it liable to surgical injury, particularly in women in whom these injuries occur almost exclusively. Its pelvic portion being incorporated in the peritoneum, except for its short distal broad ligament segment, is subject to displacements by inflammatory disease, cysts, and tumors, and is easily cut, tied, clamped, or torn when in an abnormal position. The broad ligament portion is subject to injury when operating for intraligamentary growths from the uterus or ovary or for retroperitoneal tumors, and particularly when operating for cancer of the cervix, when inflammatory reaction or metastases has involved the broad ligament lymphatics. (See section on Anatomical Relations of the Ureter.)

There is one type of cervical carcinoma in which special caution may be enjoined. In the cervical growth which develops a large mass in the vaginal portion the operator may find on exploring the pelvis that the broad ligament regions are entirely free from inflammatory reaction, and proceeding on the assumption that the case is an unusually easy one to handle, he may ignore the ureter problem only to find later that he should have proceeded, as in all cases of carcinoma of the cervix operated by the abdominal route, by isolating the ureters at the beginning of the operation. In this type of cervical involvement the mass vaults up beneath the broad ligaments and causes considerable misplacement of the distal ureter without causing any of the inflammatory involvement so much dreaded and guarded against by the careful operator.

The author has dissected and freed ureters involved in inflammatory disease, or resected and implanted others which appeared to be involved in carcinoma; but in only 2 cases has he experienced accidental injury to the ureter during a carcinoma operation, and both of these were in this type of massive, low-developing cervical growth. In the first one, occurring thirteen years ago, the unusually easy carcinoma operation was followed by complete anuria for twenty-four hours, and on attempting to catheterize the ureters both were found obstructed near the ureterovesical orifice. Supposing them to have been tied the abdomen was opened and both ureters were found not only tied but severed. Bladder implantation was done, and before the patient returned home both sides were catheterized. This patient is still in good health. The second case occurred about five years later, and in spite of calling the attention of his assistants to the ureter dangers in this type of vaulting growth, and after isolating the ureters, one of them was later picked up in its laterally displaced position and cut squarely across. An immediate end-to-end anastomosis performed over a short segment of ureter catheter, and wrapping the ureter in a peritoneal flap was followed by apparent perfect result, but the patient died from metastases in about one year.

One form of surgical injury which may be followed by necrosis and fistula, or if drainage has not been established by peritonitis and death, is the peeling off of the periureteral sheath and consequent interference with the blood supply. This is particularly likely to happen in rolling out a carcinoma of the ovary which has developed in the broad ligament region. Mention has been made in the anatomical section of the importance of preserving the overlying peritoneum whenever deliberately freeing the ureter, and in all accidental baring of the ureter one should seek to cover the surface with peritoneum before finishing the operation. On the left side the sigmoid or rectum, with its fatty appendages, may often be used to cover a defect in the outer coat of the ureter. Whenever in doubt as to the viability of an injured ureter wall, drainage should be provided, but, as Sampson,[35] in his article on "Complications Arising from Freeing the Ureters in the more Radical Operations for Carcinoma Cervicis Uteri, with Special Reference to Postoperative Ureteral Necrosis," has so well emphasized, the drains should not come in contact with the ureter, for such contact promotes necrosis.

Vaginal hysterectomy for carcinoma or for other lesions subjects the ureters to danger of injury. The only safe rule in these operations is to be certain that the bladder is well isolated at its uterovesical attachment before proceeding to tie and cut the broad ligament vessels and tissues. The author operated for repair of a ureterovaginal fistula following high amputation of the cervix by another surgeon. This fistula located two centimeters above the ureter orifice developed eight days after the cervical amputation, and was probably due to a deep ligature in the lateral vaginal vault being passed through or around the ureter.

Obstetrical injuries to the ureter are not uncommon. Occurring most often in instrumental labors, these, like bladder injuries, may be due at times to the trauma of the instruments and at times to the pressure effect of the child's head, due to the delayed use of instruments. If the leakage follows immediately after a forceps delivery we generally credit the forceps with the injury, whereas if several days elapse before the leakage begins we are justified in considering it a case of pressure necrosis.

W. C. Jones,[22] who, in addition to excellent experimental work, has carefully reviewed the literature of surgical injuries, found that accidents have been recorded in the following pathological conditions, named approximately in the order of their frequency: (1) carcinoma of the uterus; (2) myoma of the uterus; (3) ovarian cysts or other tumors, especially if intraligamentous; (4) inflammation of the adnexa; (5) congenital abnormalities; (6) extra-uterine pregnancy; (7) tumors of the bladder; (8) severe instrumental deliveries; (9) miscellaneous.

Formerly these accidents occurred most frequently in operations by the vaginal route. Today, with the dominance of the abdominal

route for pelvic surgery, most ureteral injuries occur under the eye of the surgeon.

Macnaughton Jones states that ureter injury and hemorrhage constitute the two chief dangers of hysterectomy. With the relative increase of work by the abdominal route and a growing realization on the part of surgeons of the constant menace of ureter injury in pelvic surgery, accidents to the ureter should become more rare; and when they occur they should be discovered and so managed as to reduce the consequent mortality and morbidity to a minimum.

The usual injuries named in the order of their frequency are ligation, clamping, kinking (by ligature or clamp), incision (partial or complete), resection of portion of ureter (accidental or designed), and interference with blood supply, leading to necrosis. By far the most frequent accident is the complete occlusion of one ureter (according to W. C. Jones, 80 to 90 per cent.), and this is usually by ligation, clamping, or kinking. The results of complete closure of one ureter are in the order of their seriousness to the patient: (A) Local: (1) infection, (2) fistula, (3) hydronephrosis, (4) atrophy; (B) General: (5) toxemia, (6) anuria, (7) no symptoms.

J. D. Barney[2] has collected from the literature 32 cases, and by correspondence from American surgeons and gynecologists 30 other cases of sudden and complete occlusion of the ureter by the ligature or clamp. Of these 62 cases the ureteral injury was unilateral in 46 and bilateral in 16.

The only symptom in the bilateral cases was anuria. Bilateral nephrotomy was done in two of these after forty-eight hours and ninety-six hours respectively. While there was free secretion of urine in both cases, both died in a short time after the nephrotomy. In the other 14 cases the continuity of the ureters was restored by the removal of ligatures or clamps or by anastomosis, and there was a mortality of 33 per cent.

Anuria occurred but once in the unilateral cases, the patient dying after thirty-six hours of acute uremia. Of the 46 cases in which one ureter was occluded, 10, or 21 per cent., had no symptoms referable to the injury, either immediate or remote. Renal infection after occlusion was noted in 7, or 15 per cent., of Barney's collected cases, the symptoms in all of these cases leading to nephrectomy at various periods after the primary operation. Hydronephrosis was reported in 12, or in 80 per cent. of the 15 cases observed later by operation. Fistula developed in 24 per cent., the leakage taking place through the vagina, through the laparotomy wound, or into the peritoneal cavity.

Treatment.—*Surgical.*—As before stated, ureter injury incurred by the abdominal route should be discovered and cared for at the time of operation. Such injuries are generally made in the course of serious operations, and because of the depleted condition of the patient one cannot always follow an ideal plan in their repair. We can here

discuss a few of the possible injuries and plans of dealing with them, knowing that the surgeon must fit his action in every case to the condition of the patient and to the exigencies of the injury.

Tying and Clamping the Ureter or Tying and Clamping in a Manner to Kink the Ureter.—If the surgeon suspects that the ureter may have been blocked by ligature or clamp during the operation he should take time to investigate and correct the condition. The ureter above the field of operation may show slight dilatation, which would indicate a blockage. It may be freed above the site of operation and followed downward and freed through the suspected field, or under certain conditions it may be more conservative to incise the ureter above the suspected obstruction and pass a renal catheter toward the bladder. If the ureter be obstructed the offending ligature can be quickly located and freed. In discussing this subject, one of my students made a suggestion which, so far as I know, is original and which should prove of real value in determining whether a ureter is blocked. The bladder should be catheterized by a nurse or assistant, and then if one injects a hypodermic needle of some strong coloring solution into the suspected ureter the failure of the color to soon appear in the bladder urine would mean a blocked ureter.

A ligature or clamp placed on the ureter and removed before the close of the operation will probably do no permanent injury to the ureter. Sampson[34] in reporting the first 16 cases of ligating and clamping the ureter as complications of surgical operations occurring in the gynecological department of the Johns Hopkins Hospital, cites 5 cases in which the ureter was ligated and the ligature removed before the close of the operation. In none of these were there any postoperative symptoms referable to the injury.

In 4 cases the ureter was clamped and the clamp was removed during operation. In one the clamp broke off a ureter catheter which had been placed to mark the ureter during vaginal hysterectomy. Seventeen centimeters of the catheter was left in the ureter, the patient dying on the seventh day.

In another similar case the broken portion of catheter was recovered during operation through a slit in the ureter and the patient had no postoperative symptoms referable to the ureter injury.

In a third case the broken catheter held together and was removed at the close of the operation, and a ureterovaginal fistula appeared on the third day, but healed spontaneously in three weeks.

In the fourth case the clamp was applied to the ureter during a nephropexy, but the accident was discovered and the clamp removed, and there were no postoperative symptoms referable to the injury.

The ureter was both clamped and ligated in 3 cases and the obstructions were discovered and released before the close of operation. In one of these there were postoperative symptoms of ureter obstruction which were relieved by a single catheterization of the ureter.

If the main arterial vessel has been destroyed in addition to the

crushing by a clamp in the same portion of the ureter it will be safer to provide against subsequent fistula formation by placing drainage for a few days.

Incising the Ureter.—If the continuity of the ureter is only partially severed by knife or scissors, one or more fine catgut sutures may be used to bring the incised edges together, and if deemed necessary the slit may then be reinforced with fine linen or silk in the periureteral sheath. Longitudinal wounds of the ureter heal quickly and require the simplest sort of repair.

Complete severance of continuity by incision or rupture should be repaired by uretero-ureteral anastomosis. This may be an end-to-end anastomosis an oblique end-to-end anastomosis (Bovée), an invagination of the upper cut end into the dilated lower end (Poggi), or an end-to-side anastomosis (Van Hook). There have been various modifications of the above methods, as, for instance, that of Proust and Maurer[33] modifying the Poggi method; but in dealing with an organ as delicate as the ureter with its limited blood supply from widely separated main trunks the surgeon should bear in mind that simplicity and absence of trauma are the chief factors in successful repair work.

The author prefers the end-to-end anastomosis and does this over a short segment of renal catheter about 3 cm. long. This is suspended in its middle with a black silk holding suture, and each end of the severed ureter is brought over the respective ends of the catheter segment. Four fine twenty-day catgut sutures are passed through and through as near the ureter end as they will hold, and after tying two of these the catheter is slipped out, when the other two sutures are tied. These four cardinal sutures are reinforced by two fine silk or linen threads used as square or mattress sutures, loosely tied in the periureteral sheath.

Robert L. Payne, of Norfolk (personal communication), prefers to splint the ureter ends during the anastomosis with a straight intestinal (cambric) needle. He passes this through the wall of one severed end from without into the lumen, and at a distance of about 1 cm. from the ureter end. The butt end of the needle is grasped where it enters the ureter wall with a straight artery clamp, and the pointed end then enters the lumen of the other ureter end and passes through the wall 1 cm. from the cut end. Another straight artery forceps grasps the pointed end of the needle, where it emerges from the wall. The needle splints the ureter ends with a minimum of trauma, and the forceps serve as handles for turning the various faces of the ureter for convenient suturing.

If incision of the ureter has resulted in *excision of a segment,* as sometimes happens in removing pelvic tumors, cysts, or inflammatory masses the possibility of end-to-end or any form of uretero-ureteral anastomosis will depend upon the possibility of apposing the two remaining ends. If the severed ends will not meet the surgeon has a

varied choice in his care of the upper or kidney end of the ureter. He may do nephrectomy, occlude the ureter by ligature, implant into the other ureter (transuretero-ureteral anastomosis), implant the ureter on the skin surface (dermato-ureterotresis), implant into the bowel (entero-ureteral anastomosis), or implant into the bladder (ureterovesical anastomosis).

If working in the upper abdomen when the ureter has been injured beyond the possibility of a uretero-ureteral repair one could gain a fair idea of the condition of the opposite kidney by inspection, and if this kidney seems normal and the patient is in sufficiently good condition, it may be conservative surgery to at once remove the kidney of the injured ureter transperitoneally.

The simplest method in a desperate case is to occlude the ureter by double ligation with non-absorbable ligatures and thus destroy the kidney. This should not be done unless one is reasonably certain of the integrity of the other kidney.

Barney's statistics above quoted show that sudden ligation of a ureter is far from being the safe procedure that some surgeons have claimed. Against his 21 per cent. of cases without subsequent symptoms, 15 per cent. resulted in infection and later nephrectomy and 24 per cent. in fistula formation. One case, or 2 per cent., died of acute uremia.

Some authors have advocated bringing the tied ureter into the wound in a manner to permit of its being opened in case of failure of the other kidney or to prevent serious consequences in case of leakage.

Dermato-ureterotresis.—Implanting the secreting end of the ureter on the skin surface should probably take precedence over immediate nephrectomy as well as over the method of tying and dropping the ureter. If infection occurs the better kidney will have had time to develop its compensatory activities before nephrectomy becomes necessary. In most cases the infected kidney would probably undergo hydronephrosis and gradual destruction without the necessity of nephrectomy.

A stab wound may be made in the loin and the ureter stump brought to the skin surface for a permanent fistula, or if the patient is in a desperate condition the ureter may be brought out of the upper end of the midline incision, or, better still, through a stab wound in the semilunar line. These anterior positions would entail the possible danger of intestinal obstruction, the ureter acting as a band, and the probable danger of having the ureter kinked and obstructed by adhesions. For these reasons this procedure would be considered a temporary emergency measure, serving until the other kidney could be investigated and a decision made as to the best permanent disposition of the ureter or kidney of the affected side. The greatest source of danger in bringing the ureter to the skin surface is that of a poor blood supply resulting in necrosis of the ureter end, infection of this necrosed tissue and the surrounding tissues, and final scar-tissue atrophy and

pressure resulting in hydronephrosis and pyonephrosis. We must therefore use great care and bring to the skin surface a portion of ureter that has not been badly injured, and that still retains its peri-ureteral sheath intact. It is preferable to have an excess end hanging beyond the skin surface and to watch this and trim it back if necessary.

That it is possible to have a ureter exit on the body surface without infection of the corresponding kidney is demonstrated by many cases of exstrophy of the bladder and by cases of supernumerary ureter or misplaced ureter opening in the vagina. This places the burden on the surgeon to work out a method that will preserve the kidney in these unfortunate cases.

Transuretero-ureteral Anastomosis is mentioned merely to condemn it, as it has been seriously advocated and has been successfully performed on dogs. It seems trite to affirm that such an effort in human surgery is jeopardizing the patient's last hope. We can imagine one set of circumstances in which transuretero-ureteral anastomosis might be justifiable. If one were removing a large cyst or tumor and found that a portion of one ureter had been sacrificed during the operation, and found that the other ureter had been widely dilated by pressure of the tumor, it would probably be the operation of choice to anastomose the cut ureter into its dilated fellow. If successful, such operation would result in the maximum comfort to the patient. Space does not permit an analysis of the pros and cons of such an operation as contrasted with skin implantation or intestinal implantation, the other alternatives for saving the kidney with such a combination of circumstances.

Entero-ureteral Anastomosis.—The implantation of the shortened ureter into the large bowel is an operation that has many advocates. Charles H. Mayo (personal communication from Dr. Coffey) has performed this operation in many cases, and with excellent after-results, as a preliminary measure for complete excision of the bladder for cancer. He follows the method advocated by Coffey. If a ureter has become infected and distended he prefers to bring it out on the loin.

For the cases under present consideration of ureter injury during an abdominal operation, intestinal implantation has the immediate danger of leakage followed by general peritonitis and the remote danger of ascending infection.

It has been fully demonstrated that the rectum does not rebel at service as a urinary reservoir, and that the ureters may drain into the rectum without apparent kidney infection. These important facts have been gained chiefly in work for the relief of exstrophy of the bladder, and particularly by such operations as those of Maydl[27] and Moynihan,[30] which preserve the vesical end of the ureters by implanting into the rectal wall the entire trigonal region of the bladder; and by the operation of Bergenhem,[3] also done early by Pozza, of Italy, George A. Peters, of Toronto, and Lendon, of Adelaide, Australia, which has the advantage over the Maydl operation of being done extra-

peritoneally, and which preserves the protective valve-like action of the ureter orifice by excising with the ureter a button of bladder wall. This is carried down beside the bladder extraperitoneally and implanted in the portion of the rectal wall that takes the ureter with the least tension and least torsion. This Bergenhem operation has the great added advantage over the Maydl and Moynihan operations of being far simpler and less likely to result in adhesions, contractions, and twists of the ureter.

In Zesas's[46] collection of 97 cases operated by the Madyl method there were reported 26 deaths following operation, or the high percentage of 27.

In Stevens's[41] collection of cases done by the Bergenhem method there was an operation mortality of 15 per cent. The postoperative results are about the same in the Madyl and Bergenhem operations, namely, about 65 per cent. of the patients reported living after one year and 25 per cent. having outlived a five-year period.

We are more interested in this chapter with the end results of implantation into the colon when the vesico-ureteral region cannot be preserved.

The results of operations on the human reported up to 1909 were carefully summarized by Carl Steinke,[40] and showed a mortality of over 50 per cent. Much of this could be considered as immediate operative mortality, for the successful cases included those living four weeks or more. Many cases undoubtedly lived in apparent health for a period of months or years, only to die finally from the results of kidney infection, as was the record in 2 cases (each living about four years) reported by James E. Thompson,[43] of Galveston.

Steinke found that in the extensive work done on dogs the mortality was much higher than in the human. These operations had been done by the method of direct implantation or leading the ureter directly through the bowel wall. It was at about this time that R. C. Coffey,[9] of Portland, attacked this problem in his usual logical and exhaustive manner. He had noticed the invariable result of dilatation of the bile duct after implantation into the intestine by the direct method in use up to that time, and found that this dilatation occurred in spite of a widely patent orifice. By careful dissections of the bile duct and ureter he observed that they both penetrate and run for some distance in the serous and muscular coats of the receiving viscus, and run immediately under the mucous membrane for 2 or 3 centimeters before penetrating the mucous membrane. "It was readily seen that in these organs the intra-intestinal and intravesical pressure instead of being brought to bear from within the duct, was brought to bear in a much larger area on the side of the duct, thus making a perfect valve."

Coffey then set himself the task of imitating nature by performing this physiological implantation. His method is described and illustrated as follows: "(1) The duct is located and ligated with linen or

silk. It is then cut in two above the ligature and the edges caught and held with mosquito forceps while one wall of the duct is split down with a pair of scissors, as shown in Fig. 104, *a*. A linen suture is now passed through the split end of the duct so as to include about one-half of it and tied (Fig. 104, *a*). The linen thread is then thrown around the other half and tied (Fig. 104, *b*). The loose ends are then threaded into two needles. By this method the full strength of the duct is retained for traction, while the opening is maintained by the split (Fig. 104, *c*). The end of the duct is now wrapped with gauze while the intestine is prepared for its reception, which is done as follows:

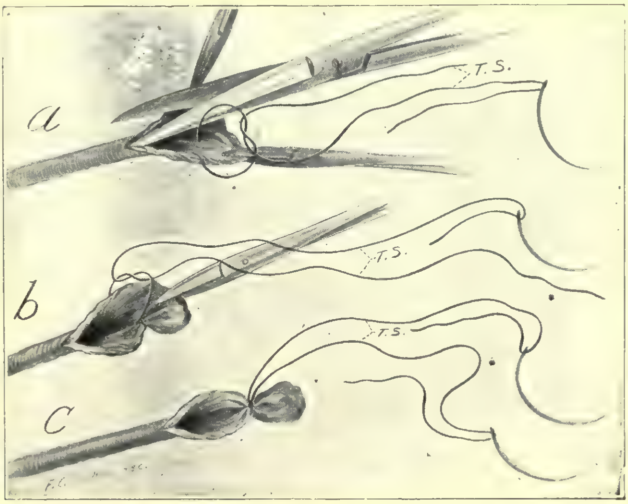

Fig. 104.—Preparing the duct for implantation into the intestine: *a*, splitting the duct to provide for drainage and tying the suture around half of the duct; *b*, tying suture around split duct; *c*, split duct ready for insertion.

"The part of the intestine desired is picked up and an incision made down through the peritoneal and muscular coats, including submucous tissue until the mucous membrane pouts out through the incision (Fig. 105). This incision should be about one inch long or more. (2) Five or six sutures are passed which pick up the peritoneal and muscular coats on each side of the incision. The suture at the upper end of the incision is tied as a control suture. The intermediate intestinal sutures are lifted up on the flat handle of an instrument as they cross the incision. Now the intestine is brought down close to the end of the split duct and the two needles carrying the threads (traction sutures) on the end of the duct are passed beneath the four or five intestinal sutures and through the stab wound in the mucous membrane into the intestinal lumen and out through the intestinal wall three-quarters of an inch farther along the intestine, and one-

eighth to one-quarter inch apart. By making tension on these threads, and at the same time pushing the intestine toward the duct, the duct is drawn beneath the intestinal sutures through the stab wound into the intestinal lumen, when the two ends of the thread on the duct are tied on the outside, thus anchoring the end of the duct on the inside of the intestine at this point (Fig. 106). The intestinal sutures are then tied, producing the result shown in Fig. 107. After this operation the duct lies just beneath the mucous membrane, which has been loosened for approximately three-quarters of an inch of its course, so that it slides easily in its new channel. It is therefore necessary to tack the ureter to the peritoneum of the intestine near its point of entrance by two or three fine linen or silk sutures. Care should be used to take only the outer coat of the ureter in the bite of these sutures. Thus practically all the steps of the operation are

Fig. 105.—Incising peritoneal and muscular coats of intestine and freeing the mucous membrane from the muscular coat.

completed before the intestinal mucosa is penetrated and no sutures penetrate the lumen of the ureter. The traction suture at the end of the ureter within the intestine and the two or three anchor sutures fastening the duct to the intestinal peritoneum are the only means of retaining the duct in place. The same intra-intestinal force which prevents regurgitation into the ureter now prevents the intestinal contents from leaking back by the loosely implanted ureter."

A summary of Coffey's experiments: "In 5 dogs in which direct implantation of the bile duct was done, all specimens showed marked dilatation of the duct without obstruction at the point of passage through the intestinal wall. Of 4 dogs in which the common bile duct was implanted by the physiological method, none showed dilatation of the duct. Of 9 dogs in which physiological implantation of the ureter into the large intestine was done, 5 recovered and were in

good health 169 days, 81 days, 80 days, 75 days, and 72 days after operation, when they were killed with chloroform. One dog died on the 13th day without discoverable cause, the implantation being

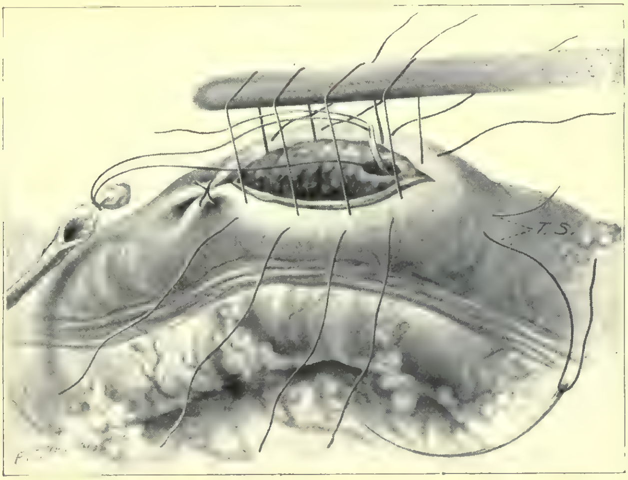

FIG. 106.—Sutures have been passed and duct is being drawn under the intestinal sutures through the stab wound in the mucous membrane.

found perfect. One died of peritonitis due to the opening of his own wound with his teeth. Two died of general peritonitis which apparently resulted from faulty aseptic technic. Of these 9 dogs, a second ureter

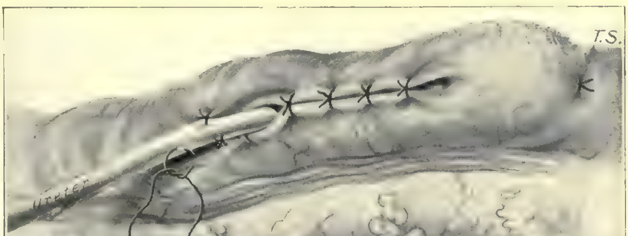

FIG. 107.—Duct has been implanted and anchored at its end inside intestine by tying traction suture (*T. S.*). Peritoneal sutures have been tied. Anchor sutures being placed to fasten duct to peritoneum.

was implanted in 1, at which time the peritoneal anchor sutures were forgotten, with the result that the ureter partially drew out, made an abscess, but still connected with the intestine by a fistula. In

this case the ureter was dilated and the pelvis of the kidney filled with pus, indicating the seriousness of omission of the anchor sutures. In 1 case the ureter in crossing through the peritoneal cavity to the intestine had been caught by an adhesion which kinked the ureter and produced hydronephrosis and distention of the ureter above this point. No distention existed below this point, and when the adhesion was broken the urine from the hydronephrotic kidney was easily forced out through the ureter into the intestine in a stream. The mechanical test shown in Figs. 108 and 109 proved that this valve was perfect, and the fact that the urine in the kidney and ureter was clear proved

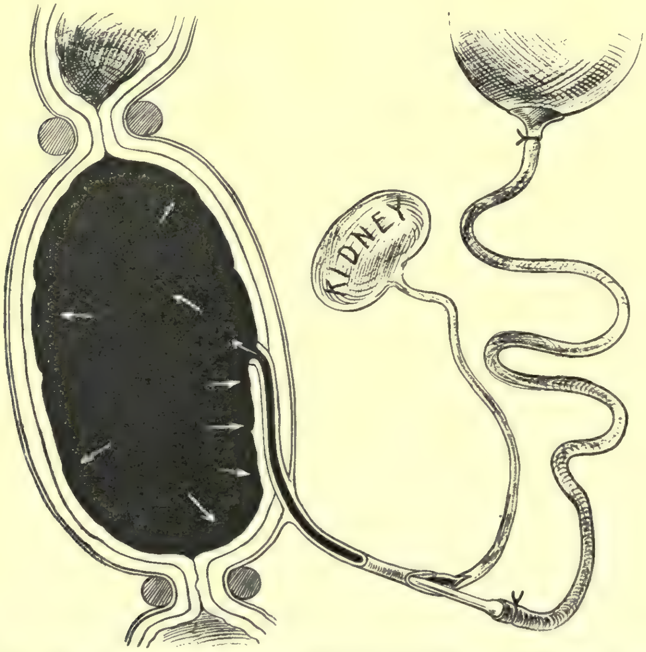

Fig. 108.—Filling with fluid a clamped section of intestine into which a ureter has been implanted by the physiological method.

there had been no ascending infection. Therefore, in not one of the 9 cases in which the complete operation as described in this paper was performed did ascending infection take place."

George R. Fowler,[14] of Brooklyn, has preceded Coffey in this type of physiological implantation by successfully transplanting both ureters in a boy, aged six years, who lived to adult life and was then lost sight of.

It is strange that the profession has overlooked this excellent operation of Fowler's, and it is evident that Coffey's search of the literature failed to discover Fowler's report. Coffey's operation is superior to Fowler's in its greater simplicity, in doing the major portion of the

operation before opening the intestine, and most important of all, in its firmer fixation of the ureter to insure against drawing back and leakage due to the strong intestinal peristalsis. Coffey advises that one ureter be implanted at a time in cases where both are to be diverted to the bowel. Coffey's experimental work on the bile duct and ureter seems to demonstrate beyond a doubt that this principle of physiological uretero-intestinal anastomosis may be used in the human subject with a degree of safety far exceeding our former experience.

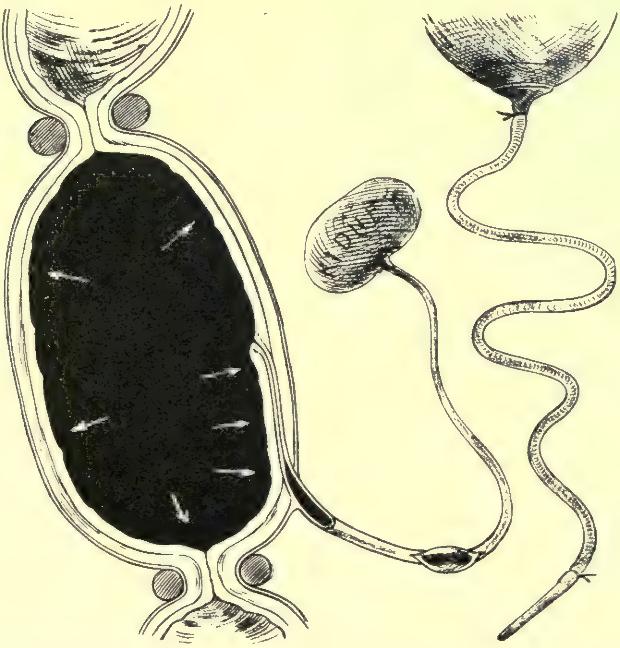

FIG. 109.—Physiological valve closed by the withdrawal of the nozzle, entirely preventing regurgitation of fluid into the ureter.

Ureterovesical Anastomosis.—If the continuity of the ureter has been severed in a low position ureterovesical anastomosis may offer the quickest and safest method of caring for the defect. This is the operation of choice in those cases in which the ureter has been accidentally severed in carcinoma of the cervix operations, and its chief field of usefulness is probably found in the cases of deliberate resection of the lower end of the ureter when this organ is invaded or closely surrounded by carcinoma extending from the cervix. Ureterovesical anastomosis is often necessary in extirpating a cancer of the bladder so located that the ureter of one side is involved in the operation. It is the operation of choice in caring for some ureterovaginal fistulæ. In performing this operation the ureter end should be slightly split

longitudinally to ensure a large opening, it should drop well into the bladder lumen, and great care should be used in passing the sutures in a manner not to kink or compress the ureter as it enters the bladder wall. Sampson emphasizes the importance of passing the sutures as far as possible through the periureteral and perivesical tissues. Care should be used to implant if possible near the base or fixed portion of the bladder to obviate kinking of the ureter as the bladder fills and empties. The bladder may be mobilized to a certain degree when the ureter is short and too great tension is threatened.

FISTULA OF THE URETER.

The causes of fistula have been chiefly covered in the above section on surgical injuries. In addition to fistulæ caused by injuries during a surgical operation, such as by ligation, crushing by clamp, cutting or tearing, robbing of blood supply, we may mention fistulæ caused by such postoperative conditions as the failure of an anastomosis (uretero-ureteral, ureterovesical, and uretero-intestinal) to hold, or necrosis from pressure by gauze drainage. Other causes of fistulæ are childbirth injuries due either to pressure necrosis, or to forceps trauma, gunshot injuries, and traumatic injuries usually associated with rupture of the bladder and fracture of the bony pelvis. Fistula following the removal of a calculus is usually of short duration, and heals spontaneously.

Classification.—We cannot do better than follow Sampson's classification:[36]

"Ureteral fistulæ may be grouped according to their etiology, and whether unilateral or bilateral, or combined with a vesicovaginal fistula. They may also be designated according to the portion of the ureter involved as, the renal, abdominal, pelvic, or vesical, and with what part of the body the fistula communicates, as the abdominal wall, uterine canal, vagina, or intestines.

"The above classifications have their importance because the symptomatology, diagnosis, prognosis if untreated, and treatment vary with these types.

"A still more important grouping of ureteral fistulæ presents itself, according to whether the fistula is total or partial, indicating by total that there is not any communication with the bladder, and that all of the urine from that kidney escapes by the fistula (Fig. 11). A partial ureteral fistula implies that a communication with the bladder still remains, either due to the fact that the ureter is not completely severed (Fig. 111), or if the ends of the severed ureter are separated, a sinus connects them (Fig. 112). The importance of this classification is evident from the stand-point of symptoms, diagnosis, and especially prognosis if untreated, because the partial ureteral fistulæ will nearly always heal spontaneously with more or less complete preservation of the function of the kidney, unless a stricture of

the ureter is present; on the other hand, the total fistulæ will continue indefinitely, or if they 'heal' it will be by occlusion of the ureter."

Treatment.—If the fistula is through an abdominal or lumbar wound, conservatism will probably call for the devising of an apparatus that can be worn by the patient for collecting the urine. Unless the ureter itself comes to the surface such cases generally "heal" after gradual destruction of the kidney. If the other kidney is in bad condition it

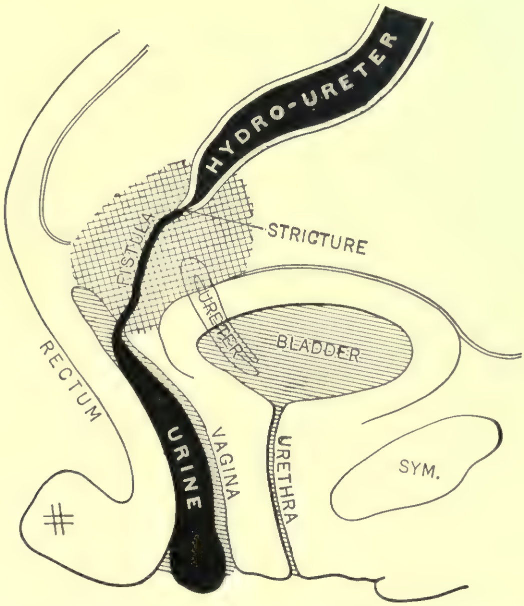

Fig. 110.—Total ureterovaginal fistula. Diagrammatic representation of one. A stricture is always present after the fistula has persisted for a short time, and infection is often present. All the urine from the kidney escapes through the vagina except as the fistula may become temporarily or permanently occluded. On palpation one may often feel the induration about the fistula. On cystoscopic examination the ureteral orifice is "dead," urine does not escape and there is no motion about it. A ureteral catheter may be passed a short distance and on injecting colored fluid into the catheter it does not appear in the vagina but flows back into the bladder (a very exceptional case might occur where the severed ends of the ureter communicated with the vagina through separate openings). The fistula persists indefinitely and if it heals spontaneously, it is only after a long period of time and with occlusion of the ureter and destruction of the function of the kidney.

may be advisable to cut down and locate the injured ureter and make an implantation in the bowel, or bring the ureter to the surface in the manner described under Dermato-ureterotresis.

Most ureteral fistulæ are of the ureterovaginal variety, and offer a wide choice of treatment. In case of persistent vaginal leakage after an operation one must first make a diagnosis between vesicovaginal and ureterovaginal fistula. By overfilling the bladder with sterile

milk or a colored solution the question of a vesical opening is easily settled.

If the bladder is intact one must determine which ureter is draining into the vagina. The conditions of the previous operation, and the location of the fistula in the vagina may furnish valuable data, but on the other hand, these suggestions may be misleading, and one must apply accurate methods of investigation. Cystoscopy may suggest

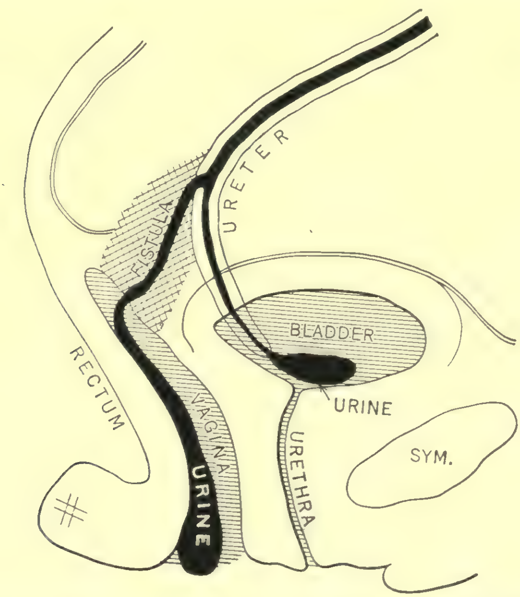

FIG. 111.—Partial ureterovaginal fistula. Diagrammatic representation of a partial ureterovaginal fistula due to a lateral opening in the ureter. A stricture may be present but often is very slight or entirely absent. The amount of urine escaping into the vagina and bladder varies with the size of the lateral opening and also the degree of patency of the ureter below the opening. On palpation one may often feel the induration about the fistula. On cystoscopic examination, urine may or may not be seen escaping from the orifice but, if it is not seen, a "tug" will usually be noticed due to the contraction of the ureter above. A ureteral catheter may be passed beyond the opening, if a stricture is not present, and colored fluid injected into the catheter, whether the end of catheter is passed beyond the opening or not, will appear in the vagina. The fistula usually heals spontaneously in a short time and often with very little stricture formation.

which ureter is injured by showing redness and edema about one orifice. One orifice may reveal normal jets of urine while the other shows no excretion or merely a slow dribble in case of partial fistula. In case of total fistula the dead ureter end will fail to show the retraction of the normal peristaltic wave.

By intravenous injections of 10 c.c. of a 0.3 per cent. indigocarmine solution one may study the ureter orifices and the vaginal fistula at the same time, and determine something of the relative functional

value of the two kidneys as well as to learn whether the fistula is total or partial and which ureter is involved. Catheterization through the bladder will probably be unsuccessful on the fistula side. If the fistula is recent and catheterization of the injured side is successful it may be well to allow the catheter to remain a few days for washing the kidney and to give the fistula an opportunity to heal, as recommended in an excellent paper by W. W. Townsend.[44] Reviewing the

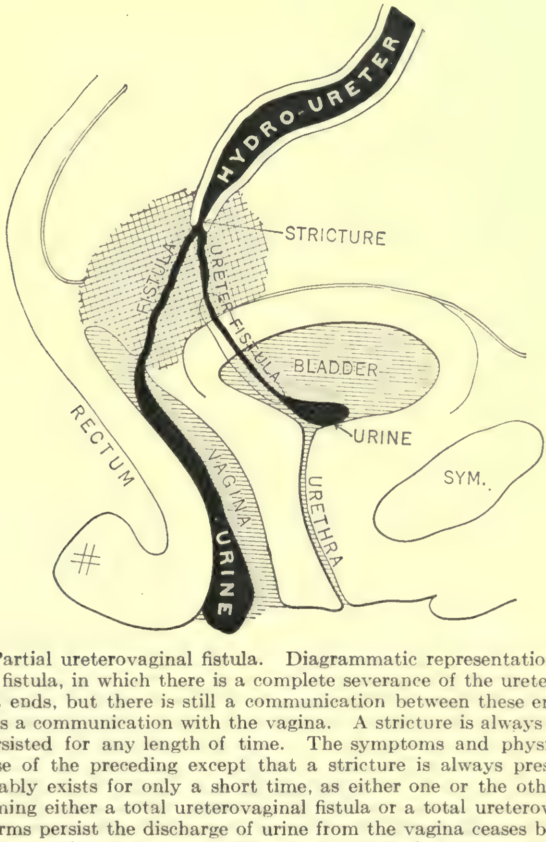

Fig. 112.—Partial ureterovaginal fistula. Diagrammatic representation of a partial ureterovaginal fistula, in which there is a complete severance of the ureter with retraction of the cut ends, but there is still a communication between these ends through a sinus, as well as a communication with the vagina. A stricture is always present if the fistula has persisted for any length of time. The symptoms and physical signs are similar to those of the preceding except that a stricture is always present. Such a condition probably exists for only a short time, as either one or the other fistula will close, thus forming either a total ureterovaginal fistula or a total ureterovesical fistula. If the latter forms persist the discharge of urine from the vagina ceases but the kidney is injured by the persistent ureteral stricture and eventually the stricture may close, thus destroying the function of the kidney.

literature, Townsend credits Jeanbreau with the first case so treated. Following a vaginal puncture for acute gonorrheal abscess a ureterovaginal fistula developed. Jeanbreau catheterized the ureter and left his catheter for six days, after which there was no further vaginal drainage.

Townsend reports 3 cases of ureter injury 2 of which were successfully treated by this method and in the third a nephrectomy was

eventually necessary. These cases were injured during supravaginal hysterectomy for fibroids (crushing ureter by clamp), removal of large ovarian cyst (ureter torn, end-to-end anastomosis), and drainage of

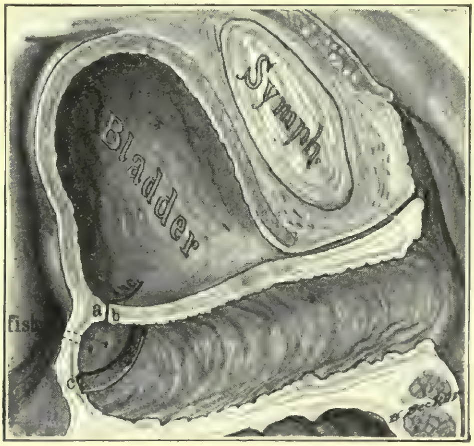

Fig. 113.—Sagittal view of end of ureter, bladder and vagina in case of double uretero-vaginal fistula. The two orifices of the ureters are shown near each other. Both ureters were cut off in an operation for cancer of the cervix and debouched into the vault of the vagina. *c* represents the strip denuded across the vagina; *a*, *b*, the incision opening the bladder. Uniting the vaginal denudation *c* to the incision *b*, the fistulæ of the right and left ureters were successfully turned into the bladder. (After Kelly-Burnam.)

Fig. 114.—Completion of operation seen in last figure. The small piece of the vagina, containing the end of ureter, is turned into the bladder by uniting the transverse incision in the bladder with the posterior denuded vaginal surface (*c* to *b*). The sutures at *a* are simply to stop the bleeding. (After Kelly-Burnam.)

an appendix abscess (ureter exposed during operation and probably injured).

To hope for a cure by this method it is probably essential that the case be treated early before the ureter epithelium has time to grow

out and meet the vaginal epithelium, thus forming a non-healing edge about the injury, and before the surrounding infiltration has time to compress the injured area. It is impossible to estimate how much the catheterization has to do with the restoration of the channel, for we know that some of these early cases heal spontaneously. Undoubtedly the "healing" in some cases whether accomplished spontaneously or by dilatation simply means that the flow of urine ceases because the surrounding infiltration has blocked the kidney. In Townsend's two successful cases he catheterized later and found the kidney of the injured side doing its normal work.

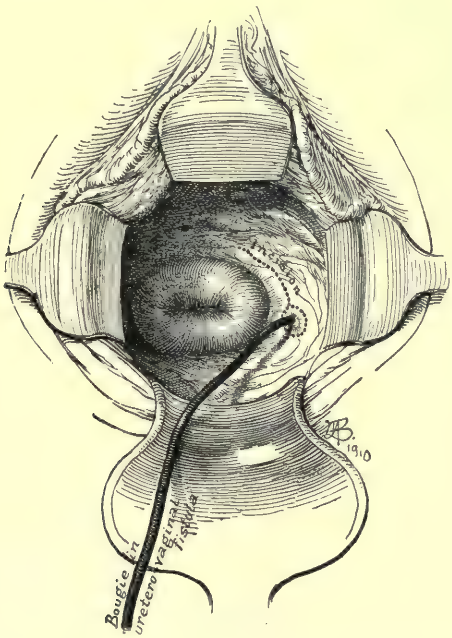

FIG. 115.—Ureterovaginal fistula. I. Catheter inserted in fistula. The dotted line shows the location of the incision for dissecting out the lower end of the ureter and implanting it into the bladder. (See following figure.) (After Kelly-Burnam.)

From our knowledge gained by work on dilatation of ureter strictures it is probable that a catheter of large calibre would find its way by the injured area more readily than one of small size. A blunt end would probably pass in some cases in which the pointed catheter would obstruct. If one is to make use of catheter drainage for several days the whistle-tip catheter is preferable, because of the extra opening on the end. In any case of such drainage the outer end of the catheter should be kept in an antiseptic solution, and lavage with a weak silver solution (1 to 3000) should be carried out at least twice a day to reduce the dangers of infection in the kidney pelvis.

A recent fistula should not be catheterized through its vaginal opening because of the dangers of increasing the kidney infection, and because the trauma may interfere with the healing efforts which if left to nature might result in closure.

In the case of an old fistula with evidence of an infected hydronephrosis, the author has greatly improved the kidney and general conditions by catheterizing through the vagina, dilating the stricture and irrigating the kidney.

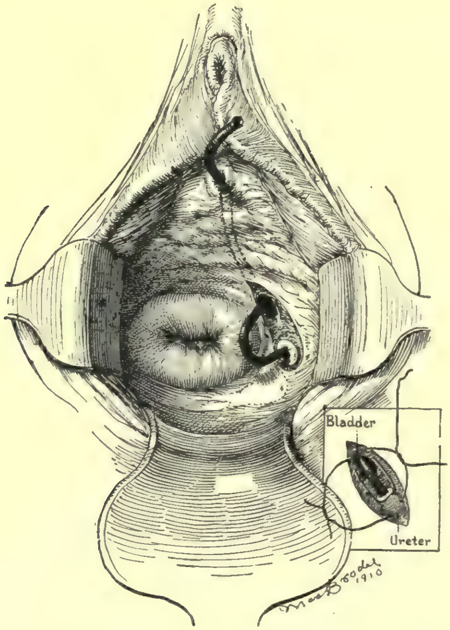

FIG. 116.—Ureterovaginal fistula. II. The larger figure shows an opening in the bladder through which the free end of the catheter has been conducted and then brought out through the urethra, by means of the open-air speculum. The lower end of the ureter is dissected free for a little distance. It is then drawn into the bladder by means of traction sutures placed as shown in the smaller drawing. It is well to add another stitch or two to hold the ureter securely in place. (After Kelly-Burnam.)

After eight weeks it is probably futile to wait for spontaneous closure of a fistula, and if investigation points to a badly infected kidney with reduced functional value, nephrectomy is indicated if the other kidney is normal.

In any case of an established total ureterovaginal fistula, in which it seems necessary to save the kidney, we have a choice of several methods of treatment. If investigation shows the kidney of the affected side to be in good condition, and the ureter to enter the vagina freely without stenosis, one may hesitate to risk further impairment of this side by any attempt at diverting this ureter into the

bladder. This is particularly true if the other kidney is in poor condition. We then advise the patient to bear with the inconvenience of the fistula, or if her social conditions are such that she is willing to forego the prospects of further sexual life, we may divert the vaginal leakage to the rectum by closing the vagina and establishing a recto-vaginal fistula. If the decision is in favor of diverting the ureter into the bladder, this may be done by the vaginal route if the fistula is in the vesical portion, or by the abdominal route if the fistula is higher in the ureter. The principles involved in diverting the ureter to the bladder by the vaginal route are well illustrated in 2 cases successfully treated by Kelly (Figs. 113, 114, 115 and 116).

Ureterovesical implantation by the abdominal route has been discussed under surgical injuries. Sampson after an experience of implantation for all causes by the extraperitoneal route in 6 cases, and by the transperitoneal route in many cases, prefers the latter route for implantations to cure ureterovaginal fistula.

DISEASES OF THE URETER.

The ureter being of comparatively simple structure, and having a simple function, is rarely if ever the subject of idiopathic disease. Its inflammatory conditions so far as we know are always secondary. In acute infections of the kidney we can practically always elicit tenderness by palpating the ureter, and we can generally palpate the wire-like thickening characteristic of an endo-ureteritis. In later stages of the kidney infection, particularly in chronic pyelitis, these evidences of ureter inflammation may be absent. In old chronic pyonephrosis the ureter is likely to be thickened and tender, but, as stated in the section on Tuberculosis, the diameter is not as great as in the latter disease and the nodular character of the tubercular thickening is absent. In some cases of pyogenic cystitis we find a thickened and tender ureter. In some cases of cystitis secondary to a tuberculous kidney we find the characteristic thick nodular ureter on the side of the tuberculous kidney and a widely thickened ureter on the other side. After removal of the tuberculous kidney and improvement of the cystitis the ureteritis of the opposite side, which probably represents periureteritis from lymphatic involvement from the bladder walls, will usually clear up promptly.

Local ureteritis is found secondary to the encroachment of cancer of the cervix or of its metastatic inflammatory products. This same phenomenon is found in association with certain cases of pelvic inflammatory disease and rarely as a sequence of appendicitis.[20] When infection of the kidney follows one of these local ureter inflammations the route of infection is problematical. There is probably a partial closure of the ureter lumen, due to swelling, and the obstructed urine may be infected directly through the inflamed ureter wall, or the infection may first reach the kidney by way of the ureter lymphatics or through

the general circulation. Any tumor pressing upon or displacing the ureter may result in stasis, dilatation, and infection. Spinal disease interfering with the proper innervation of the ureter and bladder may result in paresis, dilatation, and infection.

In the male, stricture of the urethra and hypertrophy of the prostate are fertile causes of ureter distention and infection.

The ureter dilatation and pyelitis of pregnancy are probably due in most cases to pressure on or displacement of the ureter by the growing uterus. My observations on ureter stricture show that some of these pyelitis of pregnancy cases are undoubtedly due to a preëxisting infiltration in the ureter wall.

The relation of anomalous renal bloodvessels to kinks of the ureter and hydronephrosis has been well emphasized by William J. Mayo and his associates.[28]

Neoplasms of the ureter are almost unknown except for those growths which invade from without. The most common of these are the papillomata and epitheliomata extending from the kidney pelvis and the epitheliomata extending from the cervix uteri. Sampson has found that while the ureter is often involved by pressure of the extending cervical carcinoma or its inflammatory products, the disease rarely invades through the protecting ureter sheath.

Syphilis of the ureter probably occurs more frequently than supposed, and is probably the cause of some strictures of the ureter. (See Proksch.[32])

The lesions of the blood fluke, or Bilharzia hematobia, are commonly found in the mucous membranes of the urinary tract, and are caused by the presence of the ova in the veins of these parts. Intermittent hematuria and dysuria are the characteristic symptoms, the disease occurring in this country only in immigrants from Egypt, Arabia, and surrounding countries. (See Goebel.[19])

Cysts of the Ureter.—The occurrence of multiple translucent, ovoid bodies on the surface of the ureter mucosa has given rise to a considerable literature. First described by Morgagni they were illustrated by Rayer in his atlas published in Paris in 1837, *Traités de maladies des reins.*

Since Litten's publication in 1876 the term "ureteritis cystica" has been used to designate this condition.

Von Brunn[45] advanced the now generally accepted theory that these cysts arise from the degeneration of cell nests which become cut off from the surface epithelium by connective-tissue septa derived from the submucosa. In their early stages these cysts may simulate miliary tubercles. The larger cysts may cause partial obstruction and hydronephrosis. Intermittent hematuria may occur from rupture of these cysts and the consequent opening of small bloodvessels. They have been described in the newborn, but most cases reported have been associated with inflammatory and suppurative conditions of the bladder, ureter, and pelvis of the kidney.[7]

Cystic dilatation of the lower end of the ureter was well described and illustrated by Blumer,[4] who collected 13 cases from the literature.

Fig. 117 illustrates a remarkable case treated by the author. Kelly[23] successfully treated a case in which the intermittent dilatation at the ureter orifice presented a cyst as large as the end of one's thumb by simply slitting the ureterovaginal mucosa with the alligator scissors, working under vision through the tubular speculum.

Caulk[8] treated 6 cases ranging in age from twenty-six to forty-six years; 5 of these occurred in women and one in a man; 1 was associated with double ureter and may have been congenital, while 5 were considered as acquired abnormalities. Caulk advises the resection of a portion of the cyst wall, fearing that mere slitting is not a sufficient guarantee against recurrence.

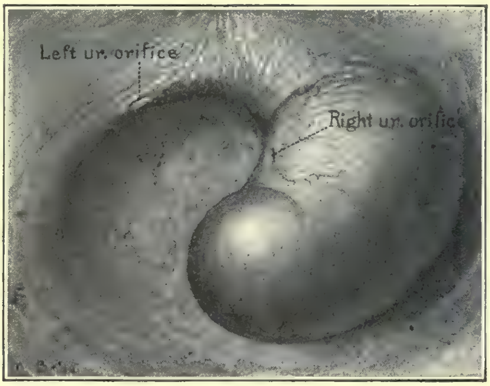

Fig. 117.—Mrs. P., aged fifty years, referred October, 1902, by Dr. J. Friedenwald. Symptoms for eighteen years simulating those of stone in the right kidney. Urine contains pus, blood, and bacteria. History of tonsillitis and rheumatism for many years. Mitral heart lesion. Repeated cystoscopy in knee-breast position showed a large mass almost filling the right half of the bladder and suggesting a large myoma of bladder wall. Palpation of bladder region negative. The patient needed operation for cystocele and relaxed vaginal outlet, so the bladder was explored through a long vesicovaginal incision. A pear-shaped cystic mass found in the right half of the bladder, which could be partially reduced by pressure. Incision into the mass was followed by a strong gush of urine under pressure. Excision of an area 2 cm. in diameter from the ureterovesical cyst wall. The middle finger easily explored the large ureter to the pelvic brim. After recovery a large No. 10 Kelly speculum could be introduced across the bladder into the new ureter orifice and a good view obtained of the ureter lumen dilated with air. (From Kelly-Burnam.)

URETER STRICTURE.

An intrinsic disease of the ureteral walls resulting in a narrowing of the ureter lumen.

One of the most common examples of ureter stricture is that due to tuberculosis, but this is practically always secondary to tuberculosis of the kidney and is dealt with elsewhere in these volumes. Another common example is the infiltration of the ureter wall surrounding a stone. This form of ureter obstruction will be discussed by another

author but I shall later refer in the section on Morbid Anatomy to the probable influence of ureter stricture on stone formation.

Incidence.—Thus restricted by the exclusion of tuberculous and calculous strictures, the discussion of ureter stricture still forms the most important chapter in ureter surgery. Up to November 1, 1915, the author's cases that may be classed as simple stricture of the ureter number 50, as contrasted with 49 nephrectomies for tuberculosis and 39 ureterotomies for stone. Since the special interest aroused in this subject by looking up past cases for a report in this chapter the author has been astonished at the number of cases one finds when thoroughly awake to their importance. With only 50 cases in the author's records of a practice of thirteen years, his records from November 1, 1915, to February 1, 1916, a period of fifteen months, shows an additional list of 50 cases.

Etiology.—The literature on ureter stricture has been concerned far too much with the conception of congenital malformation as the chief cause. (See Bottomley,[5] Eisendrath.[11])

Kelly, in 1902,[24] clearly differentiated between ureter obstruction and ureter stricture in the following lucid statement, "Obstruction is the generic term for any hindrance to the downflow of the urine, while stricture is specific in its designation, being limited to intrinsic narrowings due to disease of the ureteral walls." He further says: "Strictures are caused by an inflammation in the ureteral walls produced by the commoner pyogenic cocci, by the gonococcus, and by the tubercle bacillus. The commonest form of inflammation is that due to the tubercle bacillus, and the rarest in my experience in women is due to the gonococcus."

Garceau,[18] on the other hand, after reviewing the literature and in the light of his own experience, says, "The chief cause of fibrous stricture is gonorrheal infection."

Furniss[16] takes definite issue with the prevailing opinion that most ureter strictures are congenital in origin, and from a study of his cases, concluded that infection plays the most important part in the production of ureteral stricture. He concludes that the infiltration in the ureter is resultant on acute hematogenous infection of the kidney which often persists as a pyelitis, ureteritis, or secondary cystitis.

Furniss quotes Sugimura[42] as having studied the lower end of the ureters in the bodies of twenty-five patients who had had cystitis but died of other causes. He found changes of an inflammatory type in the submucosa and muscularis, and was of the opinion that the infection extended through the lymphatics and not along the mucosa.

Necker[31] exhibited before the Deutsche Gesellschaft f. Urologie at the Congress in Vienna in September, 1911, some pyelograms of cases of pyelitis, all showing some dilatation of the renal pelvis, and in explanation said that they were cases of ureteral obstruction with secondary infected hydronephrosis.

Kelly and Burnam,[25] speaking of traumatic stricture, voice our common experience in stating that "Traumatic stricture of the vesical end of the ureter following the injuries of labor and of surgical operations, especially the Wertheim operation for cancer of the cervix

FIG. 118.—Illustrating stricture of right ureter due to gunshot injury. Symptoms began eight years after injury. Note stricture just below the pelvic brim, and the slight dilatation of the ureter after three months of rather severe kidney symptoms. Bladder urine normal, no infection.

uteri, is quite common. As a rule the trauma has so interfered with the blood supply of the organ that there are lateral necrosis, a continuous leakage of urine, and ureterovaginal fistula. The spontaneous healing of such a fistula almost invariably means stricture."

While we must admit the possibility and probability of all the

above factors playing a role in the etiology of certain ureter strictures, I am firmly convinced that the majority of ureter strictures, excluding those of tuberculous origin, should be classified as simple chronic stricture, and that they have their origin in an infection of the ureter walls from some distant focus, such as diseased tonsils, sinuses, or teeth, or disease of the digestive tract. (See Hunner.[21])

This conception of stricture postulates that in the majority of cases the ureter infiltration is primary and that the other urinary tract lesions so often associated with stricture, such as hydronephrosis, pyelitis, and pyonephrosis, are secondary.

In only 2 of my cases (Cases III and XI) have I classified the stricture as due to gonorrheal infection. In both there was every evidence of a former gonorrheal infection, such as stricture of the urethra, trigonitis, and contracted ureter orifices, the urine being clear in both cases.

Only 3 of my cases had cystitis in spite of the fact that of the 27 cases with notes on culture-taking 18 showed infection. In 10 others there are notes of pus in the urine, and presumably they were infected, making a probable 28 cases with infected urine but only 3 with cystitis. In 1 of these (Case XXIII) the cystitis was localized in the base of the bladder, and I considered it due to the presence of a stone in the bladder.

In another (Case XXXVIII) there was ulcerative cystitis and stricture of both ureters, with dilated kidney pelves. The symptoms began three years previously without apparent etiology, her only child being three years old at the time. She had had tonsil trouble from the time she was ten until she was nineteen years of age, and I think it probable that the stricture and hydronephrosis antedated her infection and cystitis.

The third case (Case XXXIV) had ulcerative cystitis, strictures of both ureters, and colon bacillus pyelitis without dilatation of the kidney pelves. This patient dated her bladder symptoms from the birth of her last child eleven years previously. She had not complained of kidney symptoms, although her general health was bad. All forms of bladder treatment had been without avail. After my local applications for several months the bladder ulcers were much improved but refused to heal, and the urine showed a persistence of more pus than one would expect from the bladder condition. Investigation showed the upper tract lesions, and after dilatation of the ureter strictures the pyelitis promptly yielded to treatment and the bladder lesions healed completely. This is the one case in my list (with the exception of the two gonorrheal cases) that I would be inclined to classify as stricture due to cystitis. At the same time we must admit the possibility of the lesions in this case having begun with a pyelitis of the puerperium, the pyelitis possibly being dependent on obstruction caused by stricture.

It might be argued that many of these patients had a cystitis in the

past, and after absorption along the ureter lymphatics and implanting of a local ureter inflammation, the cystitis cleared up, but the histories and cystoscopy do not bear out this theory. Of the hundreds of cases of cystitis which I have treated none has returned later with a ureter stricture.

In only 1 of my cases was there an evident sequence of ureter stricture following a pyelonephritis, and in this case (Case IX) I am inclined to believe the foundation for the bilateral ureter strictures was laid by systemic rather than by local infection extending along the mucous membrane. This patient had an acute staphylococcus pyelonephritis following two weeks after an acute tonsillitis, and I followed the development of two ureter strictures in the right ureter (one 3 cm. and one 9 cm. from the bladder) within four months after drainage of the right kidney, and found two strictures of the left ureter (one 3 cm. and one 8 cm. from the bladder) a year later when the patient first began to complain of pain on this side.

While we must recognize from the writings of Schwalbe,[37] Seitz,[39] Englisch[12] and others that in the developing ureter of the fetus there are well-marked valves and folds along the mucous membrane, and that in the adult ureter there are certain areas of definite narrowing under normal conditions, we are forced by a careful study of the subject to get away from the former view that congenital abnormalities play an important role in any large proportion of cases of ureter stricture. In none of my cases have I seen reason to ascribe a congenital origin.

If stricture as we see it clinically were of congenital origin, we would expect the symptoms to arise in early life, although there would be exceptions. The average age of the 50 patients was 35.5 years and the average duration of symptoms was 4.5 years, making the average age at onset of symptoms 31 years. Of 7 cases whose history of trouble due to ureter stricture began before the age of 20 years, 5 were cases with distinct tonsillitis history, 1 of these having had her tonsils removed before, and 2 having them removed after my treatment, and the 2 still retaining their tonsils, having had acute attacks while under my care. Of the entire series a tonsillitis history or the presence of diseased tonsils was found in 24 cases. Many of the histories were taken before we had in mind the possible relationship between ureter stricture and a distant focus of infection, but most of the cases have been traced by letter or seen personally since beginning this chapter.

In 1 case the double pyelitis which led to the finding of double ureter stricture occured a few months after operation for sinus infection, the patient first coming for treatment because of rheumatism.

In 1 case the ureter stricture and its consequent hydronephrosis persisted and increased in spite of ureter dilatation until four abscessed teeth were discovered and removed.

Ten cases had stone in the urinary tract unassociated in time or region with the ureter stricture. Six of these stone cases belong in the group of 24 cases having had tonsillitis.

Nine cases had history of rheumatism, all but 1 of these coming under the groups with tonsillitis or sinusitis.

Three cases had a heart lesion, 2 of these being in the tonsil group. These facts are at least suggestive in connection with the older theories concerning the so-called "rheumatic diathesis."

The occurrence of bilateral stricture is somewhat suggestive of a systemic infection. Bilateral stricture was discovered in 12 of these cases. This condition may have been present in some others, as it has not been my custom to investigate both sides when the symptoms were confined to one side. This has been particularly true of the cases that promptly recovered after treatment of the one side bearing symptoms. The bilateral character has been discovered accidentally in some cases in the course of making a functional test. In other cases one side has been successfully treated, and at a later time the patient returned with symptoms in the other kidney, and these were found to be due to a stricture of the corresponding ureter.

Another feature in the argument for a systemic infection is the preponderance of cases in which the stricture occurred in the broad ligament region, where the ureter has its chief blood and lymphatic connections. Of the 62 ureters with stricture (12 of the 50 cases being bilateral) the stricture was located within the broad ligament or within 6 cm. of the ureter orifice in 53 ureters, near the pelvic brim in 8 ureters, and near the kidney in 1 ureter. Most of the strictures near the pelvic brim are 3 or 4 cm. below the brim, and from observation at operation they seem to be associated with inflammation in the glands situated in the bifurcation of the internal iliac artery.

It is manifestly impossible to prove the relationship between ureter stricture and a distant focus of infection, but my experience with certain cases of urethral stricture and chronic urethritis has established the proof of such relationship beyond any doubt. (See Hunner.[21]) I have now had a considerable number of chronic urethritis cases that were not due to gonorrheal infection and that would not yield to the known methods of treating chronic urethritis, but which have cleared up promptly after the removal of infected tonsils or the drainage of infected sinuses.

Morbid Anatomy.—The pathological changes in these cases have been studied chiefly at the operating table and in the gross. In 2 cases of resection and implantation into the bladder (Cases VI and XXVI) and in 1 case of nephrectomy (Case L) we have had opportunity to make microscopic studies.

These specimens show the changes typical of a chronic inflammation. The epithelium is changed from the transitional to the stratified type with the cells flattened longitudinally. The submucosa is infiltrated with small round cells of varying sizes and shapes and with leukocytes. The muscle shows degeneration by taking on a poor stain and appearing as if in hyalin degeneration. Throughout the ureter walls, including the muscle layers and periureteral sheath, are groups of small

round cells. It is possible that the leukocytes scattered through the walls are largely the result of operation.

In one specimen, that of Case XXVI, there is an area on the lumen surface bare of its epithelium and immediately beneath this there seems to be a greater infiltration of lymphocytes and leukocytes than elsewhere. This appears to be an ulcer on the mucosa.

In 8 operations of retrograde dilatation we have had excellent opportunity to examine the tissues in the gross. At the area of stricture the periureteral sheath and ureter wall proper are fused into a more or less dense mass of interstitial thickening, often carrying the impression on palpation that there must be a stone within the lumen. The areolar tissues about the ureter show inflammatory thickening.

The naturally expected result of dilatation above the stricture is found in most cases, as shown by measuring the content of the pelvis and ureter above the stricture and by a pyelo-ureterogram. The hydronephrosis is often followed by infection. It is surprising to what a degree of dilatation some kidneys attain without becoming infected.

Of 16 non-infected cases the average age was 38 years, the average duration of symptoms 2.5 years, and the average size of the kidney pelvis in 10 of the cases was 19 c.c. Three of these held 8, 11, and 12 c.c. respectively and the other 7 held from 15 to 30 c.c. In 1 exceptional case, with symptoms of four years' duration, the pelvis held 360 c.c. without becoming infected. In 5 of the non-infected cases there was no note on the pelvis capacity.

Of 18 infected cases the average age was 35 years, the average duration of symptoms was 4 years, and the average size of the kidney pelvis in 15 cases in which a record was made was 98 c.c. In 4 of these 15 cases the pelvis was of normal capacity, 7 to 8 c.c., showing for the 11 dilated cases an average capacity of 130 c.c. In the cases with both pelves dilated the capacity is figured on the larger pelvis only.

It is probable that the infection of the urine in most cases is secondary, and due to the mechanical obstruction and stasis, and therefore throws no light on the nature of the original ureter wall infection. Of the 18 cases in which cultural studies were positive, colon bacillus was grown in 13, in 5 of these from both kidneys. In 4 cases staphylococcus only was grown; in 1 case a pure typhoid culture was obtained. In 1 of the above colon bacillus cases the colon was grown from one kidney and staphylococcus from the other, making 5 cases in which staphylococcus was grown.

Ureter Stricture and the Formation of Stone.—These studies on ureter stricture have yielded several observations which promise to throw light on the etiology of at least some stones found in the ureter. Our former conception has been that the stone was primary and its surrounding infiltration secondary. I have several observations that tend to show that the deposit of urinary salts is secondary to the

disease of the ureter wall. Case XIII was referred by Dr. O. B. Pancoast in October, 1910:

Mrs. R., aged thirty-nine years, V-para, had complained of attacks of pain in the right hip and kidney region for fifteen years. On vaginal palpation a date-seed sized nodule was felt in about the line of the right ureter far out on the side of the pelvis near the obturator foramen region. On catheterizing the right kidney there was definite obstruction to the wax-tip catheter at a distance of about 6 cm. from the bladder. After getting by the obstruction the catherer entered the kidney for an unusual length, showing probable doubling in the kidney; 130 c.c. of turbid urine escaped in a steady stream. The wax tip showed marked scratches. Five days later a catheter prepared with wax tip and wax rings at frequent intervals was passed to the kidney, meeting the obstruction as previously. On withdrawal the wax tip and all the wax rings were scratched for a distance of 20 cm. from the tip, and this was 12 cm. from the external urethral orifice, or about 7 cm. from the bladder.

At operation a few days later a No. 6 renal catheter was passed to the kidney to outline the ureter. A vaginal vault incision was made and the thickened area of the ureter near the lateral pelvis was easily outlined. A blunt hook was thrown around this area, and after loosening the ureter from its surrounding adhesions it was drawn well into the wound. Two guide sutures of black silk were placed one above and one below the thickened area. A clean incision was made into this area and to our great surprise no stone was discovered. The ureter was now well dilated in both directions.

The patient probably had small stone particles in the stricture mucosa area which escaped observation at the time of operation. With our present knowledge of these conditions this ureter exploration and dilatation would have ended the operation. At that time we introduced a No. 8 catheter through the vaginal incision to the kidney and placed the patient in position for kidney exploration, which was done by Dr. Pancoast. The kidney was a thin-walled organ with large pelvis. After fruitless exploration for stone the kidney was closed and the catheter was left for irrigation of the kidney. After withdrawal of the catheter on the fourth day there was practically no urine drainage through the vaginal vault.

The patient was discharged on the twenty-fourth day, entirely free from pain and feeling much better than on admission. She returned five months later, having had much nausea and indigestion for a month, and having lost the nine pounds she gained in the first four months after operation.

Investigation showed the presence of stricture, but scratch marks were not left on our wax tip and bulb. The patient refused nephrectomy, and a recent letter says that after a few attacks she became free from her old symptoms and she expressed herself as glad she had "fooled the surgeons." Her functional tests on her first visit had shown

but 2 and 4 per cent. on two tests as compared with 16 per cent. on the left side, and her "getting well" probably meant the complete destruction of the kidney.

Fig. 119.—Case XL, aged twenty-six years, tonsillitis since childhood. Intermittent renal colic on left side for one year, on right side for three months. Stone 3 cm. from bladder on left side in dense stricture area. Dense stricture 3 cm. from bladder in right ureter. Bilateral hydronephrosis. Urine not infected.

Fig. 119 illustrates Case XL, who had bilateral stricture with a stone located in the left stricture area, this being the side of her earliest symptoms. She was completely relieved by suprapubic extraperitoneal removal of the stone and dilating of the stricture on the left side and by later dilatation of the right ureter stricture by the vesical approach.

A recent case not in my list of the first fifty demonstrates more strikingly the accumulation of urinary salts on the site of a stricture:

Mrs. J., aged thirty-seven years, consulted me February 24, 1916, complaining of attacks of pain in the left side for eight years. Recently the attacks have been as frequent as every two weeks and several hypodermics of morphin are needed to quiet them. She has never had bladder symptoms. She never noticed blood. She had a bad attack the day before consultation which morphin failed to quiet. On catheterizing the bladder the urine was dark, suggesting smokiness. It contained a few epithelial cells, many leukocytes, many red blood cells, and many rod bacilli which later proved to be colon bacilli. A catheter was prepared with wax tip and multiple wax rings. The tip was obstructed about 3 cm. from the bladder, and each ring went by this area with a jump. The pelvis of the kidney held 8 or 9 c.c. on three trials. On withdrawal of the catheter the wax bulbs came by the obstruction with repeated jumps, and each of the rings showed a series of parallel scratch marks. The next to the last bulb was the largest, being about 3 mm. in diameter and placed 15 cm. from the tip. This bulb had imbedded in the wax about a dozen small particles of urinary salts, and the eye of the catheter also brought away a particle of stone. An *x*-ray examination the same week failed to show ureter stone and at the next cystoscopy a large dilating wax bulb was passed and failed to show any sign of stone. The patient was told to watch for stone after the first examination and to note any cutting sensation in the urethra. She failed to observe any such signs and it is probable that the first examination brought away most if not all of an early formation of stone.

Another recent case not in my list of fifty is shown in the *x*-ray, Fig. 120.

In Case IX, above referred to as a case in which strictures were found in both ureters within about one year after an acute staphylococcus pyelonephritis, I discovered a stricture forming in the right ureter 9 cm. above the bladder and later one forming in the broad ligament region. This was while irrigating the patient's infected kidney during the summer of 1909. In December, 1914, thé patient again began to complain of severe pain in the right kidney, and had a fever of 102.5°. Attempts to catheterize from the vesical approach failed. I therefore undertook retrograde dilatation, and after exposure of the ureter, which at the pelvic brim was 2 cm. in diameter, there was found a band of narrowing near the iliac bifurcation which was pale white in color, densely adherent to the pelvic wall, and on being freed it was seen to constrict the ureter walls, which were considerably wider above and below this band. In other words, this was the site of the first stricture discovered five years before at a distance of 9 cm. from the bladder.

On palpating for the stricture which had been known to exist in

the broad ligament region I was surprised to find a large stone about 2.5 cm. long and 1 cm. in diameter (Fig. 121).

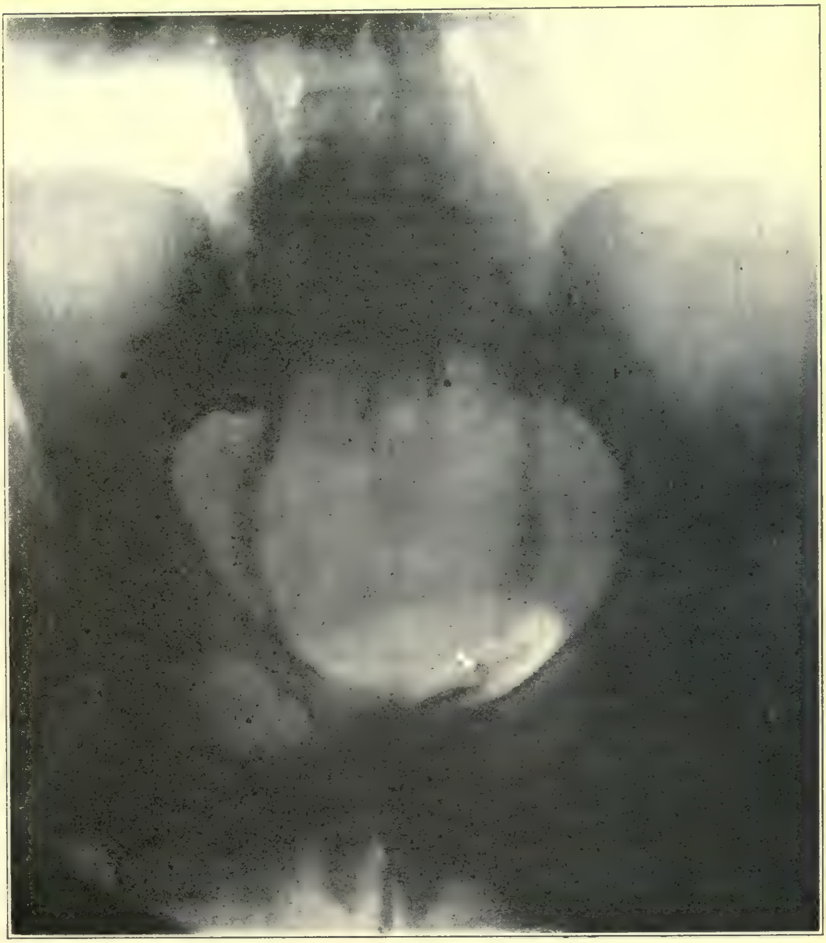

FIG. 120.—Mrs. C., aged forty-eight years. Severe renal attacks right side for eighteen months requiring much morphin. No symptoms on left side. Urine catheterized from bladder, leukocytes, erythrocytes, bacteria, trace albumin. Stricture right ureter 2 to 3 cm. from bladder. On getting thorium x-ray, found unsuspected obstruction and dilatation of left side. After withdrawing catheter from left side and finding scratch marks, the small stone was discovered in lower end of left ureter at a point symmetrical with the stricture of the right side. Examination with wax-tipped bougie twenty-four days later showed that the stone had been passed.

Another case illustrating the densely fibrous character of some of these strictures and a probable secondary formation of stone due to the stricture is that of Mrs. B., admitted to the Hebrew Hospital in March, 1912:

Case XX, aged twenty-six years, had been suffering for seven years. The urine showed pus and blood. On palpation of the lower end of the right ureter it was definitely thickened and tender, the thickening being of an elongate form, suggesting stricture rather than stone. The ureter mons region was puffy and red. A wax-tip catheter was distinctly obstructed at about 6 cm. and again at 8 cm. above the bladder; 100 c.c. of fluid was injected hurriedly before causing pain. I was then obliged to leave the patient, and the hospital resident reported a rapid return of only 20 c.c. of fluid and that the wax tip on withdrawal was not scratched. The *x*-rays (unfortunately lost) pictured two small shadows near the bladder. With these findings and a history of the patient having passed two stones previously I operated for stone.

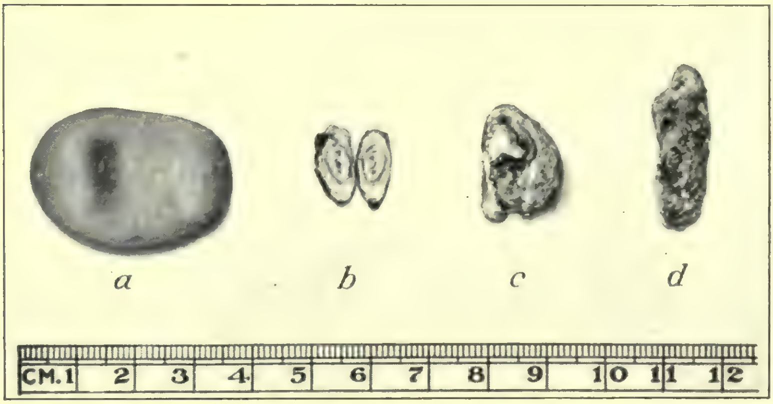

Fig. 121.—*a*, gall-stone; *b*, appendix stone from author's Case XXXVII, whose symptoms were due to ureter stricture; *c*, ureter stone from author's Case XX, showing deep channel for free passage of urine, the patient's hydronephrosis symptoms probably due to a dense ureter stricture located 3 cm. below the stone and about 3 cm. above the bladder; *d*, ureter stone from author's Case IX, removed from stricture area five years after treatment of ureter stricture.

A stone (Fig. 121, *c*) measuring roughly 2 x 1.5 x 1 cm. was found about 3 cm. below the pelvic brim, where it had been missed by the *x*-rays, the two shadows showing near the bladder probably having been phleboliths. The stone was at the upper end of a densely infiltrated area of ureter wall. Above the stone the ureter was fully 2 cm. in its outer diameter. Below the stone for a distance of 2 cm. the ureter walls were much thickened and of about 1 cm. diameter. Just below this, and at a point about 1 cm. above the uterine vessels, the ureter bulged again in a densely thickened area thought to contain stone. On cutting into this area no stone was found. After ureterotomy above the upper stone and delivery of the stone, metal dilators up to 8 mm. diameter were passed, through the upper opening down past all the stricture area and into the bladder.

The stone on one of its flat faces contained a deep groove which must have allowed a free egress of urine, and the patient's symptoms were more than likely due to the ureter stricture.

O. S. Fowler, of Denver,[15] has called attention to the possible importance of stasis in the etiology of stone formation. He attributes the stasis to a kink in the ureter, due to prolapse of the kidney, as demonstrated by the method he has done so much to develop, of taking pyelo-ureterograms in the erect posture. His roentgenograms, however, reveal ureters which are dilated below the point of kinking as well as above, and I would interpret them as being cases of ureter stricture low in the channel, causing a dilatation of the ureter and the pelvis of the kidney.

Symptoms and Diagnosis.—The diagnosis of ureter stricture is made on the patient's history of pain, the repeated demonstration of an obstruction at a certain area in the ureter, and the relief of the patient's symptoms after dilatation of this obstruction.

There are many accessory features in making a diagnosis. Of even greater importance than the obstruction to the wax tip and wax bulb as the catheter passes to the kidney is the definite "hang" of the wax bulb on the stricture area and the grating sensation imparted by the scar-tissue area as the bulb is being withdrawn through it. Fig. 122 illustrates a case with marked obstruction due to angulation in which the characteristic "hang" on withdrawal of the wax bulb was absent.

One cannot depend on the urine examination. Usually there is at least microscopic blood or pus or both, but at times these are wanting. Probably the greatest source of falling short in the diagnosis of these cases is the fact that a patient with symptoms suggestive of renal colic or ureter stone will present a negative *x*-ray and normal urine and the examination stops short of catheterization.

It is not at all rare to have one's attention directed to localized symptoms due to the inflammation in the stricture area. In addition the patient usually complains of intermittent pain in the kidney region or of bladder symptoms, or of both, and the stricture is found in the attempt to fathom the cause of the symptoms.

The pain may be more or less constant in the stricture area and intermittently grow more intense in the kidney region, and if one finds in the urine of such a case blood, or blood and pus, one is inclined to diagnose stone in the ureter until the examinations by *x*-ray and wax-tip bougie shows the absence of stone and the passage of the bougie reveals the presence of an obstruction. In such a case the ureter stricture may not be of sufficient density to cause an appreciable obstruction to the passage of the bougie on the first examination, and the diagnosis of stricture is suspected because of a hydronephrosis; or if hydronephrosis is not present the first strong suspicion of stricture may occur a few hours after the catheterization by having the patient experience an unusually severe attack of pain, or if infection be present, a severe pyelitis attack. This attack follows the swelling shut

of the mucosa at the stricture site due to the trauma of catheterization. By using a larger wax bulb at a later investigation one can definitely appreciate a point of obstruction marking the stricture area.

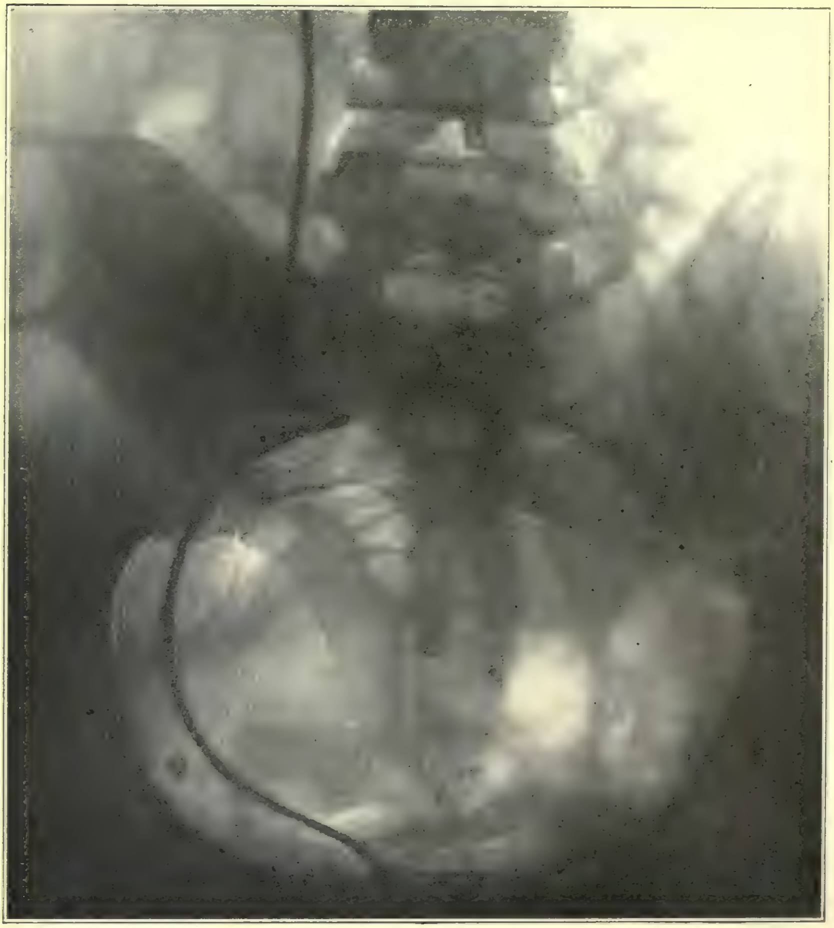

Fig. 122.—Illustrates a case with almost impassible obstruction from below but in which the characteristic "hang" and scar tissue grating on withdrawal of the wax bulb were absent. The angulation was due to peritoneal bands.

Such cases of incipient stricture and cases of stone in the ureter which give only intermittent attacks are particularly likely to have these attacks brought on by the added congestion of the menstrual period or by the congestion following getting the feet wet, getting chilled, or "catching cold." For this reason they are often diagnosed "ovarian attacks."

One can often palpate the area of thickening through the vaginal

vault, particularly in thin women, and it is quite impossible in some cases to differentiate between stone and stricture.

Cystoscopy, particularly in those cases which have a palpable thickening near the bladder, occasionally shows an edematous, reddened mons ureteris region, thus again making one quite certain he is dealing with a stone in the ureter.

It is interesting to note that a patient may have had intermittent renal colic even for years without the development of a permanent hydronephrosis. In such a case one may have great difficulty in getting by the stricture from below, and it is always surprising when one succeeds in getting by a dense stricture and fails to demonstrate hydronephrosis above. Even in those cases which fail to show measurable hydronephrosis by injection of the pelvis to discomfort and then collecting the steady back flow one can usually demonstrate by a pyelo-ureterogram the presence of a dilated ureter above the site of stricture and usually a slightly dilated and deformed kidney pelvis. When one fails to get by any obstruction by working from below, it is well to anticipate serious renal colic within a few hours because of the traumatism, and provision should be made for the patient to have hypodermic injections of morphin if necessary.

The profession has become accustomed to view slight dilatation of the pelvis and ureter as secondary to an infection of the urine. It is even held for the early cases with only slight dilatation and sterile urine that such cases came by the dilatation through a previous infection.

This view so generally held is well expressed by Braasch:[6] "Any considerable degree of infection involving the renal pelvis and ureter will be followed by dilatation. This dilatation is not caused by mechanical obstruction, but is the result of change in the tissues and consequent retraction in the walls of the pelvis and ureter. The dilatation may vary from a scarcely recognizable irregularity of the calyces or ureter to complete destruction of the pelvis. Evidence of an inflammatory process which has once caused dilatation will rarely be entirely obliterated. Such inflammatory changes in the pelvic or ureteral outline may be the only evidence of previous infection. The character and degree of an inflammatory process can often be determined better by means of the pyelo-ureterogram than by any other method."

Braasch presents a beautiful pyelo-ureterogram (Fig. 117) to illustrate a case of this so-called "inflammatory dilatation," which I should interpret as a probable case of primary mechanical obstruction, the infiltration being located in the vesical portion of the ureter. We do not always appreciate a marked obstruction in these cases on passing an ordinary renal catheter; or, meeting an obstruction, and getting by with a little manipulation, we may interpret the obstruction as a temporary angulation of the ureter wall or as the gripping of a peristaltic wave in the ureter.

In such a case if we get good final results by relieving the patient's

symptoms and having a reduction in the hydronephrosis, or perchance in curing a pyelitis by lavage, it is because the ordinary catheter has been efficacious in dilating the stricture.

An excellent illustration of this dilatation by a small instrument was furnished by Case XV of traumatic origin following a bladder instillation of too strong carbolic solution. Four years later the patient complained of symptoms typical of hydronephrosis and attempts on several occasions to pass renal catheters into the left ureter ended in failure. Finally a metal searcher got by the stricture, located between 1 and 2 cm. from the ureter orifice. On attempting to withdraw the searcher, its olive bulb tip (2 mm. in diameter corresponding to a No. 6 renal catheter) hung on the stricture so firmly that I almost despaired of getting it out. By straightening the handle of the searcher, I was able to withdraw the speculum from the bladder, and then with the index finger in the vagina, pushing on the end of the searcher, I was able by the combined push and pull to extricate the searcher. After such trauma I warned the patient that she would probably have a bad attack that night. Fortunately the stricture area did not swell shut and the patient was relieved of her hydronephrosis pains for several months. On her next visit, prompted by the return of kidney pain, I was able to get by with the searcher and then with No. 13 Garceau catheter.

It has been a not uncommon experience in suspecting stone or stricture to go by the stricture area with very little obstruction from below, but on withdrawing the catheter to have the large wax bulb "hang" obstinately on the stricture area. Hence, the contention that one may repeatedly go by a ureter stricture with the ordinary renal catheter and interpret the slight obstruction as an anatomical or physiological obstruction so often met in ureter work.

One should be on the alert for the presence of stricture of the ureter in any case of pyelitis that seems to be particularly resistant to lavage treatment (Fig. 123). Especially is this true if these lavage treatments are followed by acute pyelitis attacks with high temperature, chills, pain, nausea, vomiting, etc. By passing larger bulbs in such a case one can appreciate the stricture if such be present, and the pyelitis attacks following lavage will cease because of the free opening of the ureter channel at the point of stricture. Of several cases in which this point has been impressed, I shall detail only two.

In Case XLIII, who developed pyelitis attacks about eight months after having an operation for infected sinuses, I was much disappointed over her resistance, for several weeks, to the strong silver nitrate irrigations.

This patient had suffered for about four months with intermittent attacks of chills, fever, severe headaches, and profound prostration. She had never had renal colic, and her physician, Dr. N. G. Orchard, of Rochester, N. Y., was led to suspect the kidneys only because of the urinary findings.

On admission she had a colon bacillus infection with moderate pyuria on the right side and a very slight pyuria without infection in the left kidney.

Fig. 123.—Arthritis attacks for past ten years. Treated in New York three years ago for antrum trouble. Pyelitis attacks for past four years. Colon bacillus infection of left kidney which resists lavage treatment with silver nitrate. On several of the first six treatments the catheter was slightly obstructed, but stricture was first suspected because of resistance of the infection to lavage treatment. A large wax bulb demonstrated stricture 4 cm. above ureteral orifice. Kidney pelvis holds less than normal content, but pyelo-ureterogram shows slightly dilated ureter.

After four lavage treatments with 1 to 1000 silver nitrate solution both kidneys were free from leukocytes, but the right kidney still grew a colon culture.

Treatment of the left kidney was discontinued and lavage of the right side was kept up about twice a week with 1 to 500 silver nitrate solution with varying fortune—the patient occasionally having a profound chill, high fever, and prostration within twenty-four hours of the irrigation, and the urine after these attacks showing considerable pus.

At the first two examinations I had made a note that the wax bulb was obstructed in the region of the bladder wall both on insertion and on withdrawal, but for some reason (I suppose because of the former absence of kidney symptoms and because of normal-sized renal pelves) I had not been impressed with the possibility of ureter stricture. On one occasion, after about five weeks of treatment, I used a No. 8 renal catheter without a wax bulb, and for a few days following the patient had her most severe pyelitis attack.

At about this same time the patient said she suspected her left kidney of again having trouble, and on investigation I found it had developed a colon bacillus infection.

On passing large wax bulbs I found that both ureters had dense stricture areas just above the ureter orifice, and from this time on for four weeks, until we had banished the infection with irrigations with 1 to 500 and then 1 to 100 silver nitrate solution, the patient had no further reactions after treatment.

After leaving the hospital July 15, 1915, this patient enjoyed remarkably good health until an attack of la grippe in November. This, together with rather strenuous home and social duties, resulted in a lowering of her vitality, and while visiting in Baltimore the first week in January, 1916, she had an attack of pain in the lower left abdomen accompanied by diarrhea, a temperature of 102°, and a chill.

She entered the hospital, where we found the urine quite negative to microscopic and culture investigation. After a few days in bed she was greatly improved, and I investigated both ureters, finding the resistance to large wax bulbs, but no evidence of hydronephrosis and no pain reaction after the examination.

Case XLIX was referred by Dr. Hugh T. Nelson, Jr., of Charlottesville, Va. By correspondence I learned that this patient had but one kidney which pyelography (Fig. 124) had shown to be the seat of hydronephrosis and that she had a colon bacillus infection of the urine, and often had chills, high fever, and great prostration, particularly after lavage treatments which had been carried on intermittently for ten months. With this history I ventured the diagnosis of ureter stricture, which was not being sufficiently dilated with the ordinary renal catheter.

On seeing the patient and getting a full history my views were strengthened, and I would think that she had lost the other kidney because of ureter stricture coming on very early in life and probably due to tonsillitis.

She had suffered with tonsillitis since earliest childhood and had had

her tonsils removed. In 1901, when aged twenty-two years, she had an atrophic kidney shell removed from the left side by Dr. Finney at the Johns Hopkins Hospital. She had suffered distinct attacks of the left hydronephrosis since two years of age, the attacks in more recent years coming less often and lasting about four days, with the appearance of a mass in the side, constant pain, headache, and loss of appetite. The mass would disappear rather suddenly, and for several days the patient would void large quantities of cloudy urine.

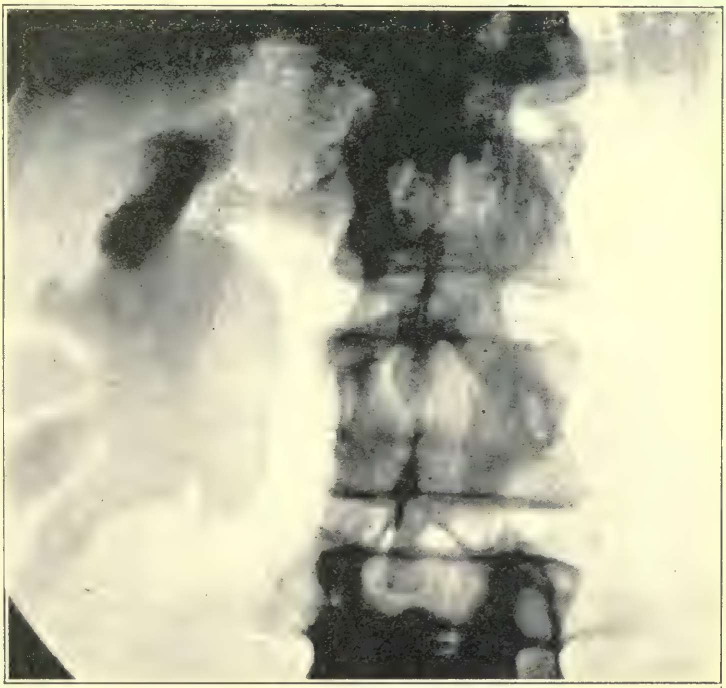

Fig. 124.—Case XLIX. Tonsillitis since early childhood. Left hydronephrosis attacks since two years of age. Destroyed left kidney removed in 1901, at age of twenty-two years. Hysterectomy for fibroids January, 1915. Convalescence marked by pyelitis attacks in right kidney. Intermittent lavage for ten months often followed by severe pyelitis attacks. Pyelogram, Charlottesville, Va.: Right kidney pelvis holds 40 c.c.; ureter stricture well dilated October, 1915; colon bacillus infection and all symptoms gone December, 1915.

Early in 1915 the patient had a hysterectomy done in Richmond for fibroid uterus, and during her convalescence she developed the symptoms of pyelitis.

I saw the patient first on October 14, 1915, and found that she had a dense infiltration area in the bladder portion of the ureter, and that the kidney held 40 c.c. of fluid. The urine contained only a few leukocytes, but yielded a pure culture of colon bacillus.

At my first examination I passed only a 3 mm. wax bulb and washed

the kidney with 1 to 1000 silver nitrate solution. Within twenty-four hours she had a slight chill and a rise of temperature to 103°. At subsequent treatments I used wax bulbs of increasing sizes, and she never had further reactions after the treatments. She had two washings with 1 to 1000 silver nitrate solution, two washings with 1 to 500, and two with 1 to 100 without ridding her kidney of the infection. She then went home for the Christmas holidays and returned on December 28, when the urine was entirely free from leukocytes and negative to culture.

Before she went home the hydronephrosis had contracted from 40 c.c. to 30 c.c., and it remained at 30 c.c. on her return. I think it fair to assume that her clearing of infection was due in large measure to the establishment of free kidney drainage, and it would probably have occurred without the lavage treatment. The comparatively slight reduction in size of the pelvis of the kidney after free opening of the ureter suggests a hydronephrosis of long duration, and an incidental infection after her hysterectomy ten months previously.

Treatment.—The ideal treatment for stricture of the ureter is by dilatation from the vesical approach. Naturally those whose work is confined to women and those who use the Kelly speculum have a great advantage in treating this disease. Various forms of operative cystoscopes and ureter instruments have been devised by Bransford Lewis and others which makes it possible to do considerable effective work from the vesical end in the male.

My work being confined to women I shall speak only of the methods which I have used in treating stricture, these having been largely developed or suggested by Dr. Howard A. Kelly.

A glance at Fig. 125 will show the simple instruments which I use, entirely with the tubular speculum of Kelly. As a rule, I use the olive-tip catheter of sizes 7, 8 and 9, carrying a wax bulb 8 to 10 cm. back of the wax tip end (*b*). Not infrequently the olive-tip catheter refuses to pass when a round tip (*a*) or a whistle tip (*c*) will engage the lumen and go by the stricture. One may use the ordinary whistle-tip catheter with the wax bulb or the whistle-tip catheter with a gradually increasing diameter which Garceau devised for the special purpose of making functional tests (*c*). This Garceau catheter in sizes 11 or 13 gives a fairly good dilatation without adding the wax bulb.

At times these catheters engage the lumen of the stricture area better with the wire stylet left in for stiffening, and at times a slight withdrawal of the stylet will result in success when the catheter has seemed permanently obstructed.

In case of failure to get by with any of these forms of flexible catheter it is sometimes possible to make the first entrance with the metal searcher (*f*). By slightly curving the last centimeter of the metal searcher one can gently rotate the angled handle, thus giving the tip a variety of axes in one of which it will engage and pass the stricture

where the more flexible instruments will meet a pocket or shelf of mucosa and permanently obstruct. Usually after getting through the stricture area with the olive-pointed metal searcher one can withdraw

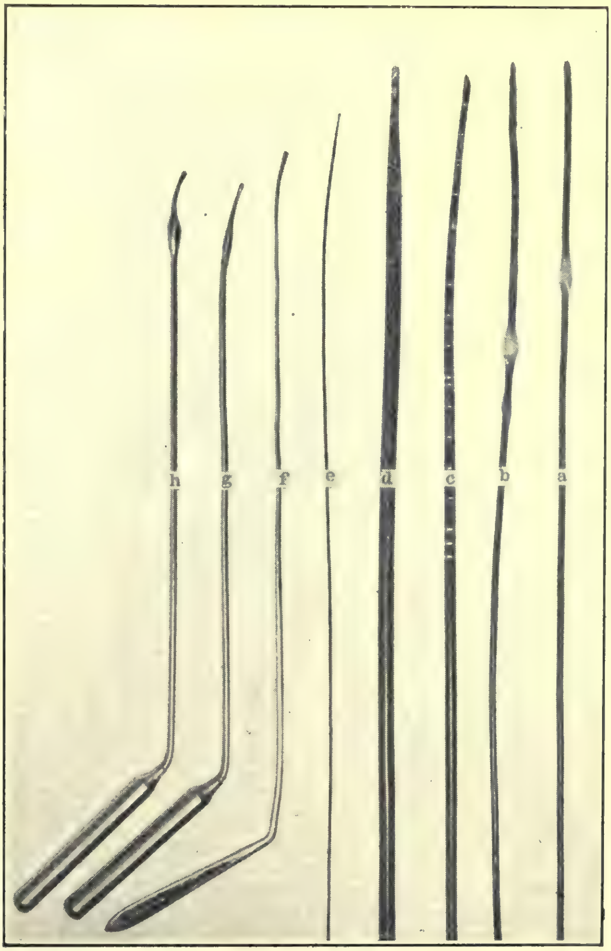

FIG. 125.—Set of ureteral catheters, etc., used by author. *a*, blunt round tip renal catheter with wax bulb; *b*, olive tip renal catheter with large wax bulb protected on either side with smaller bulb; *c*, Garceau graduated whistle-tip catheter; *d*, flexible bougie (7 mm. diam.). Sizes vary from 3 to 10 mm., the smaller sizes being useful for dilating through the cystoscope from below, and the larger sizes for retrograde dilatation from above; *e*, whalebone filiform (varying sizes are used through the cystoscope); *f*, metal searcher with olive tip; *g*, metal bulb dilator 3 mm. with curved olive tip; *h*, metal bulb dilator 5 mm. with curved olive tip.

the searcher and immediately get by with one of the flexible catheters which has previously obstructed; or one can follow the metal searcher with the metal bulb dilator (*g*) which has a slightly curved olive tip

followed by a metal bulb of 3 mm. diameter, which bulb gives such thorough dilatation that the flexible catheter is quite certain to pass. At later treatments where a still greater dilatation is wished, the metal bulb dilator of 5 mm. diameter (*h*) may be used. It is seldom necessary to use this large metal bulb, for one can easily use the flexible catheters with a wax bulb as large as 6 mm. diameter. In using these very large bulbs it is well to see that the bulb is of perfect spindle-shape, having no abrupt shoulder to catch on the stricture, and also to place smaller bulbs immediately in front and behind the larger bulb to give partial dilatation before the large bulb engages (*b*) In recently using a large bulb with rather an abrupt shoulder on the distal side the bulb was obstinately hung at the stricture area on its withdrawal, and it brought with it a perfect collar of mucous membrane which had been torn from the mucosa because of the abrupt shoulder. This, of course, creates most objectionable trauma in the site of the stricture.

In our earlier work in testing for stone in the ureter we always used beeswax (the cera flava or cera alba of the *Pharmacopœia*) mixed with one-third or one-half sweet oil, but I found that this softens the wax to such a degree that it partially crushes on meeting a narrow ureter orifice or later on meeting the stricture; sometimes on withdrawing the

Fig 126

catheter a part or all of the wax is left on the proximal side of the stricture. For this reason I have given up the mixed wax and oil and use only the pure beeswax. This is soft enough to get a good impression from stone, and it is firm enough to hang to the catheter and not crush under any ordinary conditions of obstruction.

At times, on failing to get any of the above instruments to engage a stricture, I have succeeded in making the first dilatation by using the whalebone filiform searchers (Fig. 125, *e*). Usually the first two or three searchers catch in the mucosa just as the other instruments have done, but after introducing three, four, or five filiforms one can, by careful manipulation, get one of them through the stricture lumen, when by further manipulation the others will follow.

After dilatation with from two to four filiforms one can withdraw these and pass the renal catheter with the bulb, but it is generally safer to leave one or two of the filiforms as a guide and pass the metal searcher or the flexible catheter alongside the filiforms to engage the stricture lumen before the guides are withdrawn.

Before beginning work with the whalebone filiforms one should have sterile hands or put on a sterile glove, for these have to be grasped close to the speculum at a portion of the filiform that later enters the bladder or the ureter.

The advantages of the beveled end of the whistle-tip catheter, of the pointed end of the olive-tip catheter, and of the different axes obtainable by using the metal searcher with slightly curved tip, I have learned by experience to combine in what may be called the "corkscrew" or spiral wax-tip catheter (Fig. 126). By dipping the olive-tip catheter in melted wax and allowing the small drop to cool on one side and just back of the tip, one combines the advantages of rather a sharp point and a shoulder to give the whistle-tip effect. Then by dipping a heated curved artery forceps in the melted wax a larger lump or shoulder can be formed on the opposite side of the catheter at a slight distance back of the first drop. This second and larger shoulder acts as a fulcrum to lift the tip around in different axes in case it fails to find the lumen with the first drive. At times one can actually feel the catheter revolve as this spiral tip finds its way through a scar-tissue obstruction.

Results of Treatment by Vesical Approach.—What can we hope for in the simpler non-operative forms of treatment? In the cases without infection and without much renal disturbance we can look for cure. Such was the result in 8 of my cases. The case numbers, the duration of symptoms, and the pelvic contents before and after treatment are shown in the following table:

Case No.	Duration of symptoms.	Pelvis before treatment.	Pelvis after treatment.
XV	A few weeks	30 c.c.	3 years later; 15 c.c.
XVII	5 years	22 c.c.	2 years later; 9 c.c.
XXI	2 months	15 c.c.	5 months later; 7.5 c.c.
XXII	5 years before passed ureteral stone	28 c.c.	5 months later; 10 c.c.
XXVII	2 years	30 c.c.	Not seen after three treatments and complete relief of symptoms.
XXVIII	9 years	15 c.c.	3 years later; no further renal attacks; is pregnant third time since treatment.
XXXV	18 months	22 c.c.	4 months later; 10 c.c.
XL	3 months	40 c.c.	Not seen after two treatments.

In certain other cases, even with infection, if the pelvis of the kidney is not too dilated we get brilliant results in permanently clearing up the symptoms and the infection through dilatation and lavage. This occurred in 5 of my cases, 2 with bilateral stricture and pyelitis.

Case No.	Duration of symptoms.	Pelvis before treatment.	Pelvis after treatment.
XXXIV	11 years	Bilateral and no dilatation	Free of pus and bacteria.
XLI	1 year or less	30 c.c. staphylococcus	Free of pus and cocci; pelvis contents 8 c.c.; six months later.
XLIII	4 months	Bilateral, colon, no dilatation	Free of pus and bacteria.
XLVII	Pyelitis 1 week	15 c.c.; colon	Free of pus and bacteria.
XLIX	10 months	40 c.c.; colon	Free of pus and bacteria; pelvis contents 30 c.c.; two months later.

In other cases with infection and large pelves we may be unable by lavage to rid the patient of infection, probably because of the permanently sacculated pelves, but we may place them in apparent perfect health by doing away with the ureter obstruction thereby relieving their pain and their toxic symptoms. Case XVI was admitted to the Johns Hopkins Hospital, July, 1912, suffering with repeated chills and a hectic fever ranging as high as 104° F. The right kidney had a capacity of 100 c.c., and yielded a turbid purulent urine. The left kidney held 120 c.c., and was secreting a thick, turbid urine as of a pyonephrosis. Both ureters had two or three infiltrated areas near the bladder, and cultures revealed colon bacillus from either side. After dilating the strictures and washing the kidneys with silver nitrate solution the patient promptly improved and left the hospital after three weeks feeling well and with urine from each kidney showing only microscopic pus and bacteria. This patient has remained in good health, and for the past two years I have seen her only two or three times a year. On November 15, 1915, the patient came at my request and had dilatation of both ureters. The urine was macroscopically clear, but contained microscopic pus and bacteria. The right pelvis took 40 c.c. to the point of discomfort and the left took 50 c.c., each side returning 45 c.c. in a steady stream,

In the following 3 cases with infection the patient's symptoms were relieved by treatment, but I have been unable to follow them with cystoscopy to learn of the final kidney condition:

Case XIV, with attacks of pain in the kidney for two years, enlarged, inflamed tonsils and arthritis, had a stricture about 3 cm. from the bladder and pelvis of the kidney of 12 c.c. capacity, with a staphylococcus infection. After a few dispensary treatments she was lost track of.

Case XXIV had a stone in the bladder with symptoms referable only to this. The x-ray picture revealed another small shadow in the left ureter region. On investigation this shadow was found to be outside the ureter, but the ureter had a stricture in the bladder portion and another about 4 cm. from the bladder. The kidney pelvis held 21 c.c. and was infected with colon bacillus. After a few treatments the strictures were well dilated and the pelvis reduced to 14 c.c. The patient went to her home in North Carolina before the infection was cleared, and a recent letter, almost four years after her treatment, states that she is perfectly well.

Case XLV consulted me in August, 1915, when she was three months pregnant. She had had the symptoms of a pyelitis for four days. Palpation in the left ureterovesical region revealed a small mass taken to be a calculus. The left mons ureteris was swollen and red and measured 1 cm. in diameter, being elevated above the surrounding mucosa $\frac{1}{2}$ cm. The metal searcher discovered a grating as of stone or stricture just within the ureteral orifice. The metal telephone catheter failed to sound stone. The stricture was dilated first with the 3 mm. and then with 5 mm. metal bulb dilator, the latter splitting the mucosa somewhat

and causing bleeding. The pelvis of the kidney held 18 c.c., and the urine from the kidney was smoky, turbid, containing pus, blood, and bacteria. Unfortunately a culture was not taken. This patient was a physician's wife, and as her symptoms cleared within two or three days I have not seen her since. Her labor is due about the last of February and her husband reports that the urine is perfectly normal.

In another group of 3 cases each with bilateral infected pyelitis the method has not had a fair trial because of a failure of the patients to persist with treatments after securing enough dilatation to free them from the severe attacks of pyelitis.

Treatment by Operation.—If all the methods of vesical approach fail, we must consider the operative relief. No form of operation will be undertaken until as complete investigation as possible has been made of both sides. Stricture of the ureter is so often bilateral that we cannot afford to take anything for granted in dealing with these cases.

If investigation shows stricture of but one ureter, associated with a kidney of little or no functional value, conservatism usually calls for extirpation of the injured or dead kidney. This was done in 6 of my cases with entirely satisfactory results.

If the stricture is high at the junction of the kidney pelvis with the ureter we may follow Fenger in doing some form of pyelo-ureteroplasty. Actual stricture at this point is extremely rare and the valve-like obstruction formed by floating kidney can usually be overcome by mere high fixation of the kidney, as I have done in a number of cases with excellent results.

If careful examination at the time of operation leads one to suspect an organic narrowing at the pyelo-ureteral junction a pyelotomy and careful dilatation may be done in addition to the kidney fixation, or if the pelvis is very large a partial pyelectomy may be done, being careful to dilate if the orifice into the ureter is at all narrowed.

If the stricture is lower and about the lumbar or pelvic brim region it has been recommended to sever above the stricture and implant into the colon or to bring the ureter out on the loin region.

If the stricture is low and near the bladder, as a vast majority of these strictures are, it has been the custom to implant the severed healthy end into the colon or bladder.

Coffey's brilliant results with uretero-intestinal anastomosis in the dog and Charles Mayo's successful colon transplants in the human have been referred to under the section on Surgical Injuries; but in the type of cases under discussion the problem is particularly difficult, for in a large proportion of them the ureter is enlarged above the stricture, making intestinal implantation difficult, and the kidney is already infected or has its resistance so lowered that intestinal infection is invited.

I have done bladder implantation in 2 of these 50 stricture cases with indifferent or questionable results in both. I say "questionable results," because in neither case could I later enter the ureter with a catheter from below. Both cases have been in good health since the

implantation, but I suspect in both of these cases there may have formed stricture at the site of the implantation with gradual destruction of the kidney.

Retrograde Dilatation.—I wish to emphasize a method for handling these cases by operation which I have not seen mentioned in the literature, but which I am sure must have been done by some surgeons and which has probably been described before, namely, the treatment by retrograde dilatation. Certainly, every surgeon must follow his ureter stone extractions by dilatation of the usual area of infiltration about the stone.

The ureter is exposed by an extraperitoneal incision, incision is made into its dilated portion above the site of stricture, and increasing sizes of the French gum-elastic bougies (Fig. 125, *d*) or metal sounds are passed until the stricture is dilated to a diameter of from 5 to 7 mm. The ureter incision is then closed with catgut, reinforced, if thought necessary, with silk or linen. A wick drain is usually left in the extraperitoneal incision for forty-eight hours to take care of possible contamination by the escaped urine at the time of operation, or of postoperative leakage and the excessive serum secretion following the extraperitoneal operation.

If the dilatation has not been entirely satisfactory, or if there has been much trauma to the ureter, I leave it open or close it carelessly with catgut to favor urine drainage in case of temporary swelling shut of the traumatized stricture area. In such cases two or three small wicks are dropped to a point near the area of ureter incision and left some days or until there is certainly no urine leakage.

A McBurney incision is suitable for most of these cases, but a semilunar line incision is more useful, for it can be enlarged up or down to suit the exigencies of the case, and through a moderately long semilunar line incision one can easily palpate from kidney to bladder.

I have treated 8 cases by this retrograde dilatation, 5 cases in which it was impossible to dilate from below, 2 cases in which stricture of the ureter was found when stone was being looked for, and in 1 case in which ureter stricture had been successfully treated from the vesical approach one year previously, but in which the stricture again swelled shut sufficiently to cause kidney symptoms in the course of an attack of acute gonorrheal salpingitis.

The results in these 8 cases treated by retrograde dilatation have been perfect in 6, so far as measured by relief of symptoms and ability to easily catheterize later from below.

The cases least suited for retrograde dilatation are those in which previous testing of the capacity of the pelvis of the kidney and ureter, and pyelography have shown an absence of marked enlargement of the lumen above the site of stricture. In these cases the ureter is found too small above the stricture to admit large dilators, and if it is at all possible to get by from the vesical approach one should be satisfied to do as well as possible by this route, although it may require a long, tedious course of treatment.

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SECTION III.

THE KIDNEY.

CHAPTER IX.

By WILLIAM C. QUINBY, M.D.

ANATOMY AND PHYSIOLOGY OF THE KIDNEY.*

EMBRYOLOGY OF THE KIDNEY.

In the embryology of the kidney the Wolffian body, or mesonephros, plays a conspicuous role during the earlier developmental stages. In the higher forms of life the Wolffian body disappears, to make way for the permanent kidney, or metanephros; while in lower forms, such as fishes and amphibia, it continues to be the excretory organ throughout life. In the very earliest stages of the embryo the Wolffian body is itself preceded by a more rudimentary type of excretory organ, the pronephros. Both pronephros and Wolffian body are paired organs, lying longitudinally on either side of the midline of the body cavity. As the pronephros is gradually absorbed from above downward, the Wolffian body is growing; and the excretory duct of the pronephros becomes later the Wolffian duct.

With the advent of the permanent kidney the Wolffian body degenerates, insofar as it has to do with the urinary system. Its duct gives origin to a lateral bud from which are developed the ureter, pelvis and collecting tubules of the permanent kidney. This is situated at the lower portion of the duct. In the female the rest of the duct becomes vestigial but in the male it is preserved under a changed function as the excretory duct of the genital system, where it forms the epididymis, vas deferens, and seminal vesicles.

The development of the permanent kidney begins at about the fourth week of embryonic life as a differentiation of a group of cells situated at the lower portion of the Wolffian ridge, called the nephrotom, or mesonephric blastema. These cells quickly give rise to the formation

* I am greatly indebted to my friend Mr. Max Brödel, Associate Professor of Art as Applied to Medicine in the Johns Hopkins Medical School, for permission to reproduce several of his splendid drawings illustrating the subjects dealt with in this article.

of rudimentary glomeruli and a tubular system, which soon become united to the pelvis and ureter about and around the growing ends of which this kidney blastema lies. The development of the kidney parenchyma and tubules is somewhat complicated. It has been most carefully and completely elucidated by Huber, to whose article the

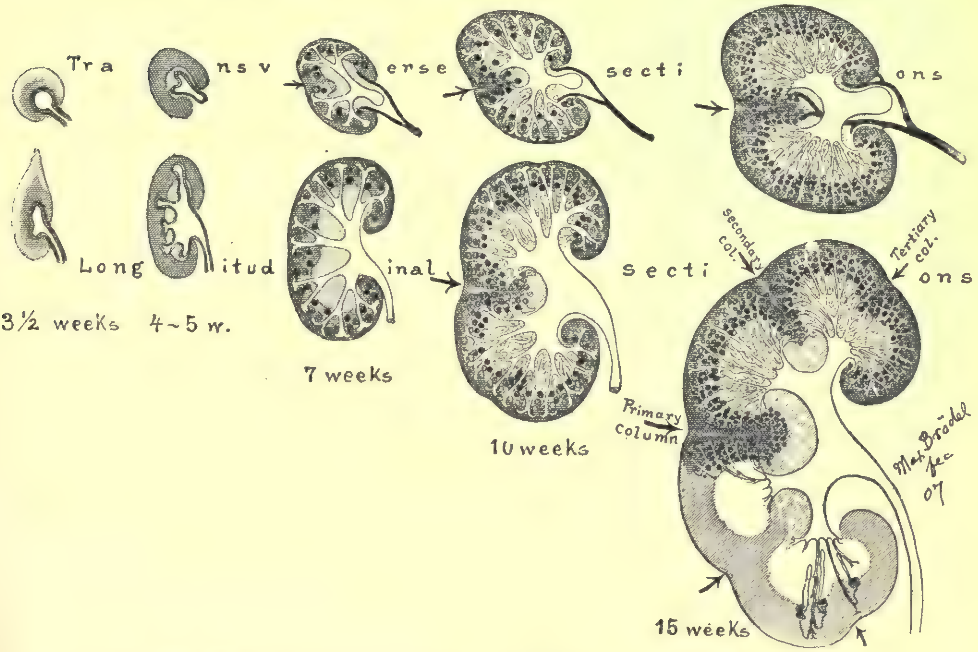

FIG. 127.—The development of the renal parenchyma. (From Brödel, in Kelly and Burnam's Diseases of the Kidneys, Ureters and Bladder, New York, 1914.) *Three and a half weeks:* The ureteral ampulla surrounded by kidney blastema. *Four to five weeks:* The ureteral ampulla branching; note the sinus renalis as a lighter zone of connective tissue appearing between the branching ureter and the kidney blastema. *Seven weeks:* Ureteral branches traversing sinus renalis in greater numbers. Note their end ampullæ just under the surface. First sign of glomeruli in central zone of cortex. *Ten weeks:* Increased number of ureteral branches. Longitudinal and transverse wedges of cortical substance, the future renal columns, pushing their way into the sinus renalis. *Fifteenth week:* Great number of ureteral branches. Their lumina are much reduced owing to their greater numbers and on account of the loops of Henle growing down from the cortex between the collecting tubules. We have thus the beginning of the medullary substance. New wedges of ingrowing cortex are formed subdividing the groups of ureteral branches (calices), whose number thus increases to six or eight. The primary cortical columns are the deepest, the secondary less deep, the tertiary quite shallow.

reader is referred for a detailed description.[6] He finds that the epithelial bud at the lower end of the Wolffian duct gives rise to the ureter, the pelvis, the calices, the papillary ducts, and the collecting tubules; while the kidney blastema is the origin of the convoluted tubules, the Henle loops, Bowman's capsule, and the glomeruli. Stated briefly, and as will be seen in Fig. 127, the process is one of continued

branching of the ureteral ampulla, accompanied by successively down-growing areas of the parenchyma of the cortex toward and into the sinus renalis. These wedge-shaped columns of cortical cells,

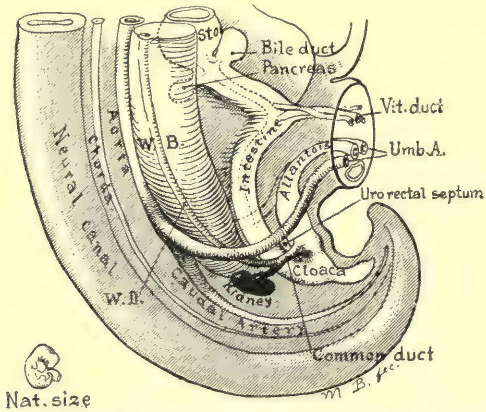

FIG. 128.—The kidney in an embryo about four weeks old. (Kelly and Burnam.)

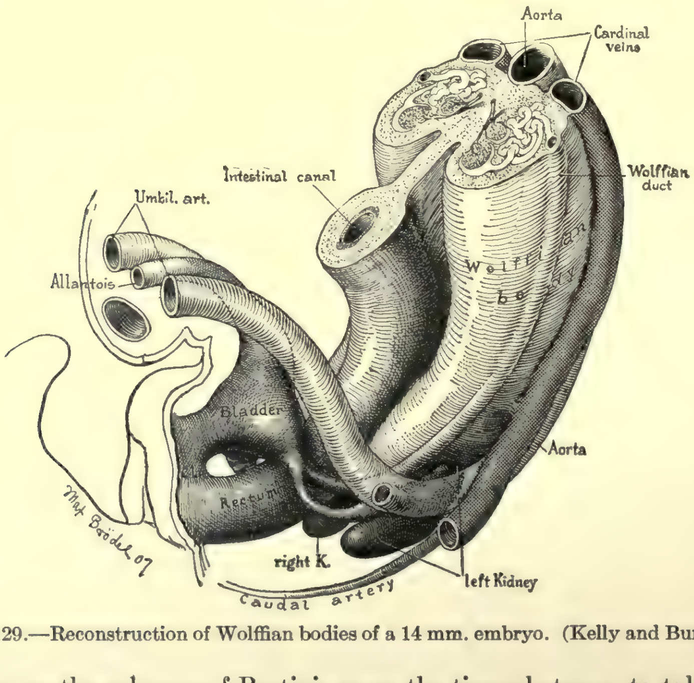

FIG. 129.—Reconstruction of Wolffian bodies of a 14 mm. embryo. (Kelly and Burnam.)

known as the columns of Bertini, cause the tissue between to take on the shape of pyramids. Furthermore, their ingrowth causes the kidney to have a lobulated surface during fetal life, and for a short time after birth.

As it is first seen the kidney lies in the developing pelvis of the embryo, below and behind the umbilical vessels, the allantois, and the cloaca. Its longitudinal axis at this stage is approximately vertical,

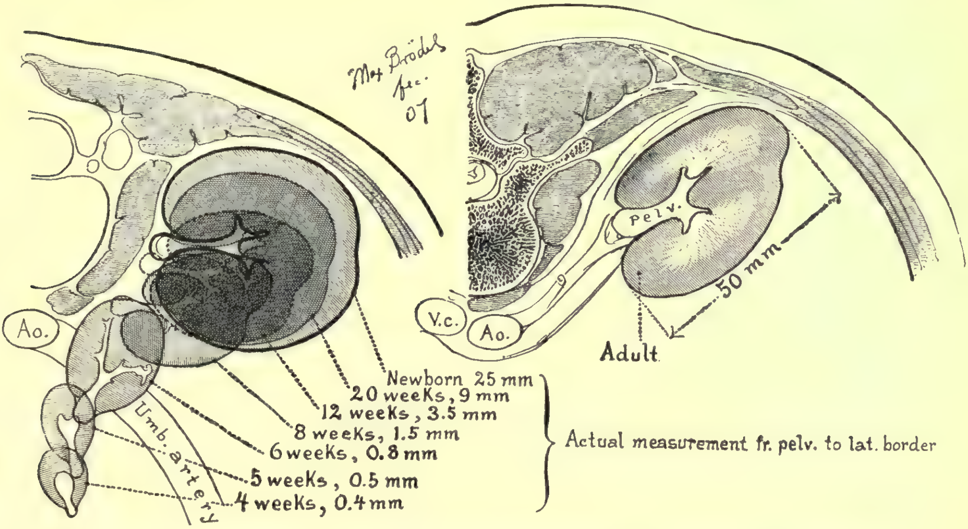

FIG. 130.—The change of the transverse axis of the kidney. Figure to the left shows change from fourth week to newborn; that to the right, the adult. (Kelly and Burnam.)

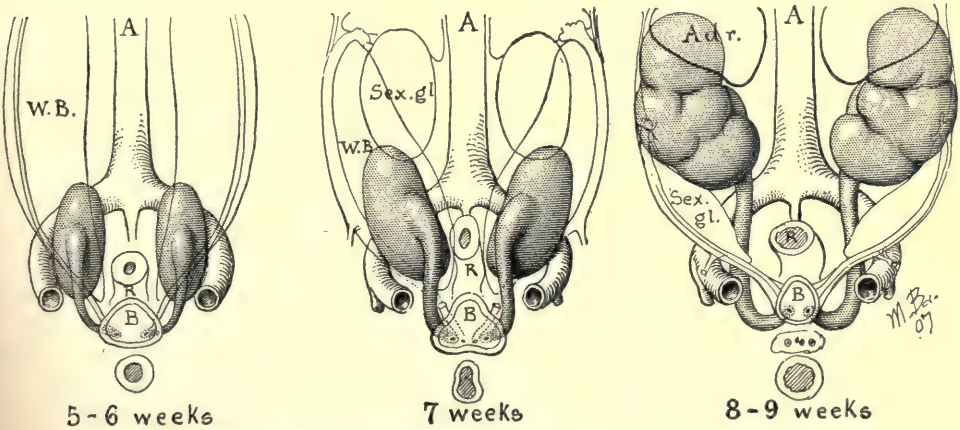

FIG. 131.—Diagrams showing the ascent of the kidneys out of the pelvis. Note how at first the renal pelves are in front; later turned toward the midline, finally turned posteriorly. Fusion of the lower poles at seven weeks produces horseshoe kidney. (Kelly and Burnam.)

and its transverse approximately anteroposterior (Figs. 128 and 129). By continued growth the kidneys gradually pass up out of the pelvis, and during this time they are rotated so that when about midway of the

ascent the transverse axis is more oblique, from without inward, with the lower poles much nearer each other than are the upper. It is a persistance of this position which is seen in those cases of abnormal fusion of the two organs called "horseshoe kidney." During further ascent to their final positions, the transverse axes are rotated so as to run from without forward and inward, to intersect in the midline, in front of the vertebral column (Figs. 130 and 131).

This ascent of the kidney is complete at about the eighth or ninth week of fetal life. During this migration it is supplied with capillary bloodvessels from the neighboring tissues. The lower of these go, while newer ones come into the organ from higher levels, until the transposition is completed. The final renal arteries are those enlarged capillaries which were most advantageously placed at the time that the kidney had nearly reached its final position. There may be two renal arteries; especially in those instances where there is a double pelvis. Also a supernumerary artery going to the upper pole is not very infrequent. In all cases, however, the bloodvessels adjust themselves to the position of the growing parenchyma.

ANATOMY OF THE KIDNEY.

The kidneys are two large, glandular organs situated on each side of the vertebral column, behind the peritoneum of the upper abdomen. Their exact level, though it often varies, is usually given as from the eleventh thoracic vertebra to the upper border of the third lumbar vertebra, on the left; while on the right, the position is lower by from a half to a whole vertebral level. In the female both kidneys are lower by about half a vertebra.

The surface of the kidneys is smooth, being covered by a firm layer of fibrous tissue, the tunica fibrosa, which is closely applied to the surface of the organ. The inner layer of this capsule contains a network of smooth muscle fibers. It is easily separable from the underlying renal tissue.

Each kidney lies in a greater or less amount of loose fatty tissue, the capsula adiposa, which is in greater amount about the margins of the organ than in front or behind. This fatty tissue contains the vessels and nerves of the kidney before they reach the hilus, and is continued with them into the sinus renalis. A loose sheath of fibrous tissue, the fascia renalis, surrounds the kidney and a considerable amount of its fatty capsule.

The shape of the kidney is usually likened to that of a bean, flattened anteroposteriorly. The upper pole is broader and thinner than the lower pole, the external border is markedly convex, the medial border slightly concave. On the latter at about its middle is the hilus renalis, a fossa going deeply into the organ, through which the renal artery enters, and from which the renal vein and ureter emerge. The hilus

is prolonged as a deep slit, the sinus renalis, running into the organ in a longitudinal direction, and forming the pelvis (Figs. 132, 133 and 134).

The anterior surface of the kidney is convex. On the right it is in relation with the right suprarenal body, the under surface of the liver, the descending portion of the duodenum, and the hepatic flexure of the colon. That portion of this surface which is apposed to the liver is covered by parietal peritoneum. On the left, the anterior surface is in relation with the left suprarenal body, the stomach, the spleen, the

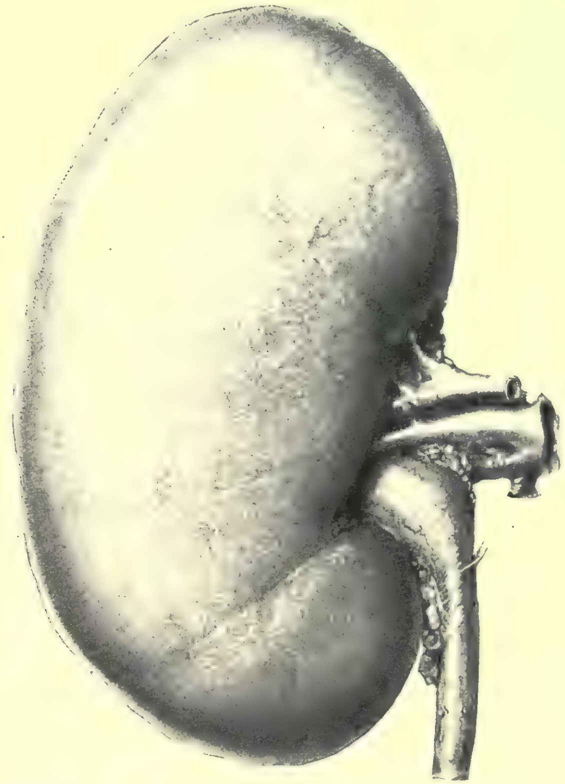

FIG. 132.—A normal left kidney; posterior view. (Brödel.)

pancreas, the jejunum, and the splenic flexure of the colon, or a portion of the transverse colon just internal to this. Those areas of this surface apposed to the spleen and stomach are covered by peritoneum; that covering the latter forming part of the omental bursa. The peritoneum also covers the area below the pancreas, being fused with the transverse mesocolon (Fig. 135).

The posterior surface of the kidney is also convex, but shows a somewhat flatter curve than the anterior. It is in relation with that part of the diaphragm which arises from the lumbocostal arch, with the

psoas major, the quadratus lumborum, and the transversus abdominis muscles (Fig. 136).

Most authorities describe separate indentations or furrows on the exterior of the kidneys corresponding to the organs or muscular structures surrounding each area. These are usually only found in organs which have been hardened *in situ* after death; for during life the kidney is a somewhat expansile organ, varying its size and surface contour to meet the differing amounts of blood flow.

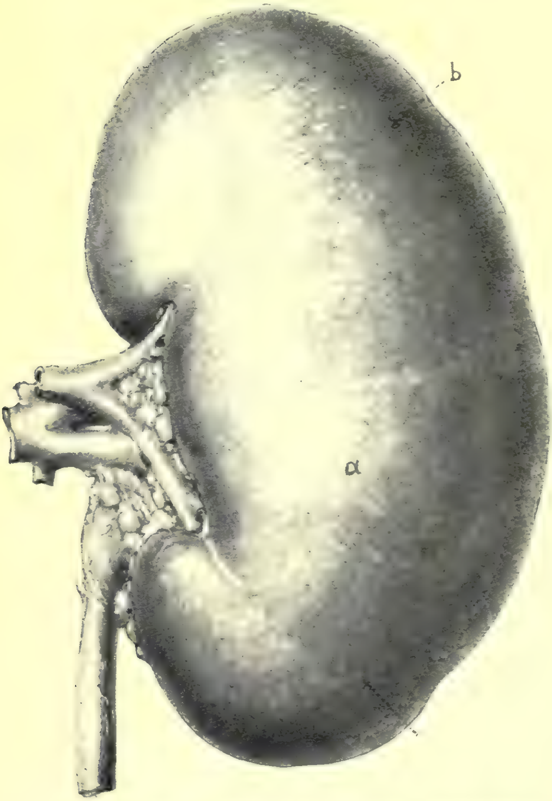

FIG. 133.—A normal left kidney; anterior view. (Brödel.)

FIG. 134.—A normal left kidney; lateral view. (Brödel.)

On section the kidney tissue is seen to consist of two layers, the cortex and medulla. The medulla surrounds the renal sinus and is made up of a number (average 35, Spalteholz) of conical-shaped masses of tissue with their base toward the periphery, known as the pyramids. Their apices end in the form of papillæ, projecting into the renal sinus at the beginning of a calyx. The apices of the pyramids become fused, so that each papilla represents two or three pyramids at the centre of the kidney, and six or more at the upper and lower ends.

The number of papillæ is about nine on the average, varying from six to fourteen. The cortex, relatively much thinner than the medulla, covers the bases of the pyramids in a continuous layer, and in the form

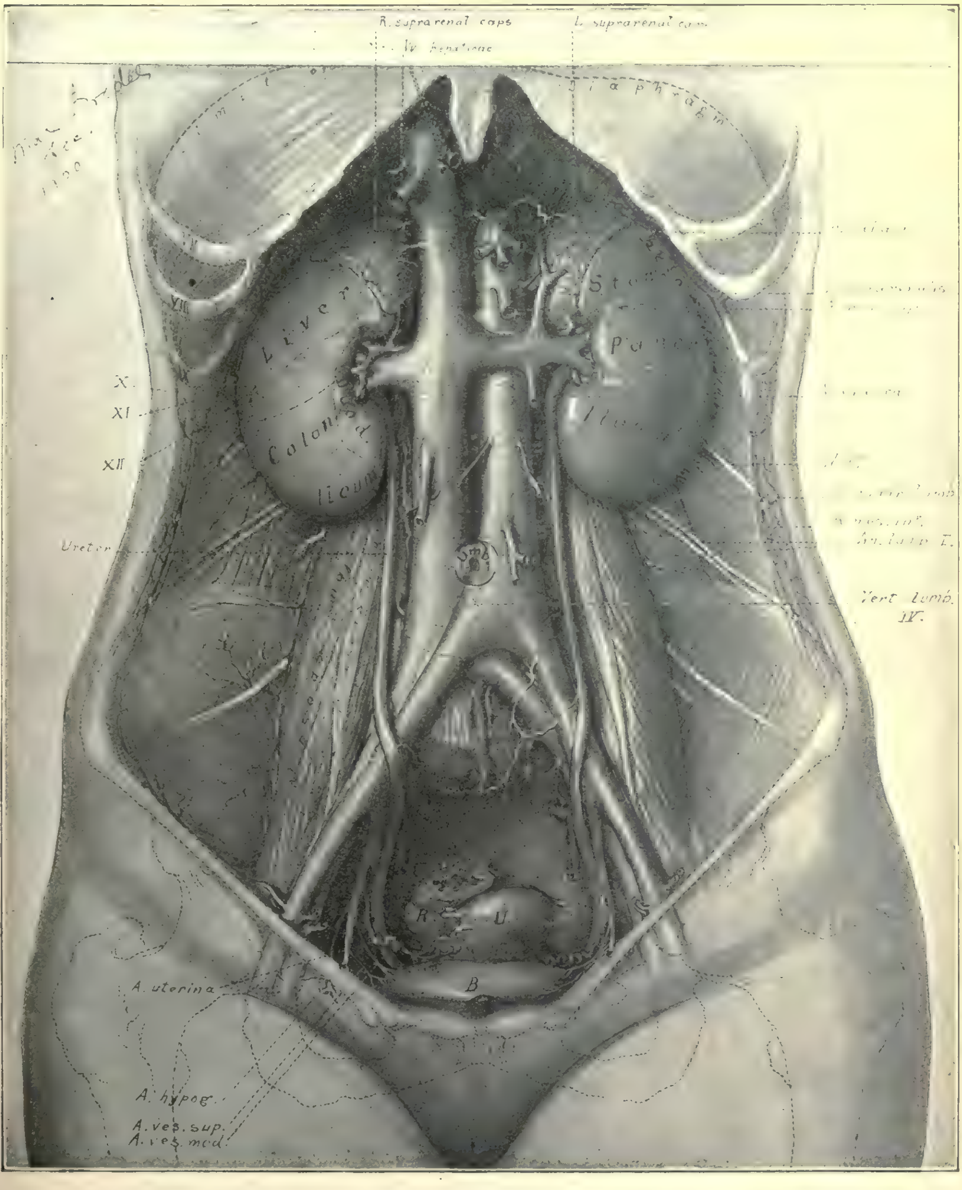

FIG. 135.—The position of kidneys, ureters and bladder. Front view: abdominal viscera removed.

of renal columns (Bertini) sends central prolongations between them toward the sinus renalis (Fig. 137).

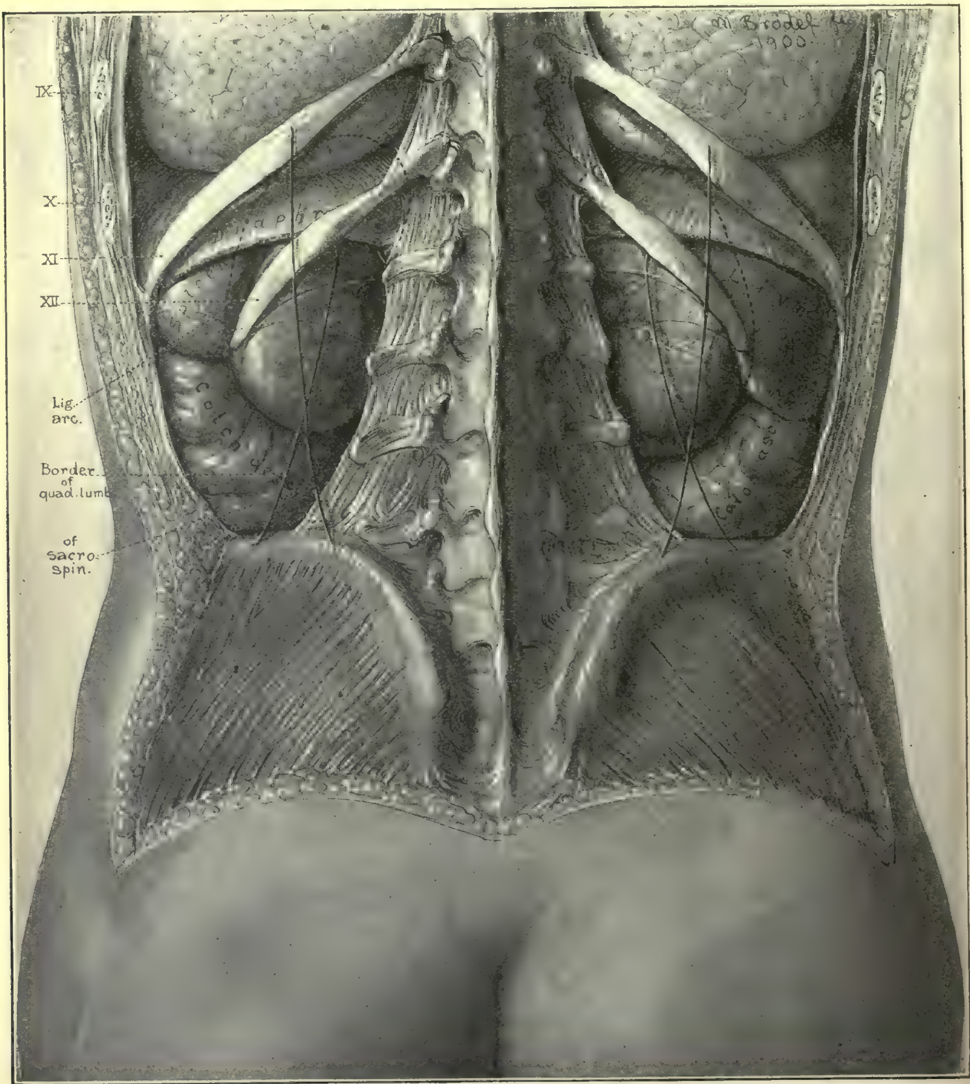

Fig. 136.—Posterior view of body, integument and muscles removed. Note relations of viscera and lines indicating outer borders of m. sacrospinalis and m. quadratus lumborum. (Kelly and Burnam.)

The color of the cortex and columns is a reddish brown. The pyramids are more violet and dark, except at their apices which are lighter. The pyramids contain only straight collecting tubules,

derived from the epithelium of the excretory duct system, as was pointed out in the section dealing with embryology. The urinary tubules of the cortex and renal columns, on the other hand, are partly straight, partly tortuous.

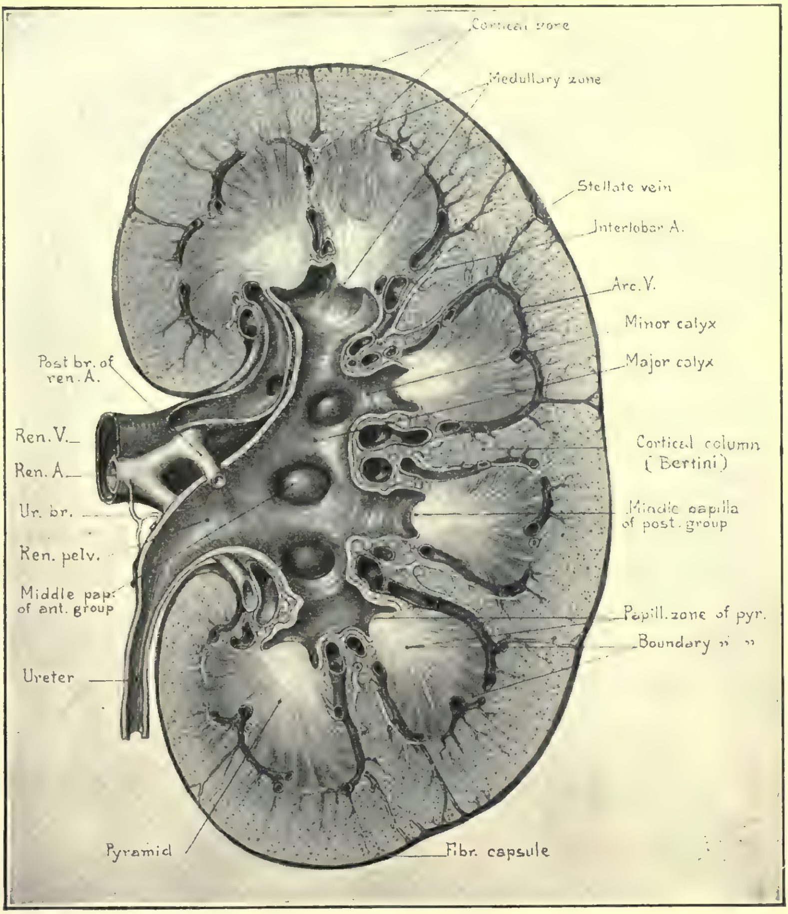

Fig. 137.—Longitudinal section through human kidney, showing gross anatomy. (Kelly and Burnam.)

The cortex is made up of a vast number of lobules, columnar in shape, which extend from the medullary substance of the pyramids to the periphery. The margins of these lobules are made by the radially directed interlobular arteries and veins. At the centre of each column is a lighter strip, the pars radiata, or medullary ray, formed of straight tubules. Between these, making up the rest of the lobule, the tissue is of a darker color, consists of tubli contorti, and is known as the pars convoluta.

Each papilla of a pyramid opens, usually singly though sometimes in pairs at the upper and lower ends, into a short, narrow tube, the minor calyx. Several of these unite to form one short, broad, major calyx of which there are usually two, less often three; and these major calices, in turn, unite to form the renal pelvis. The pelvis and calices, major and minor, are subject to very considerable variation. In the majority of cases the pelvis is seen as a flattened tube, broad above,

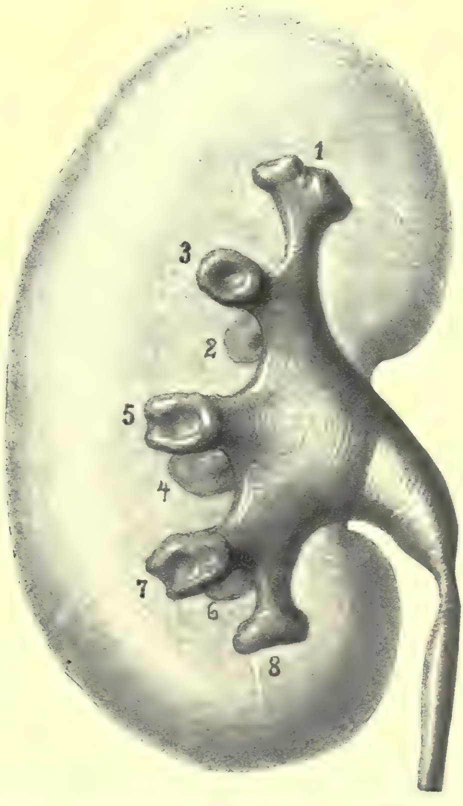

FIG. 138.—Left kidney drawn as though transparent, showing form and divisions of true pelvis. The major calices are not very marked, the minor calices being situated directly upon the pelvis. Posterior view. (Brödel.)

curved downward, and narrowed below. Its transition into the ureter may be either gradual or sudden, and it may project out of the renal hilus for a considerable distance; or it may be almost entirely within the hilus, only the ureter showing beyond this. Not very infrequently, also, the pelvis is found double. This occurs in cases of double ureter, or when the ureter divides some distance before reaching the hilus.

The number of minor calices varies from four to twelve, the most

usual number being six or eight. The number of papillæ is usually somewhat greater than this, owing to the twin or triple papillæ in the upper and lower calices, as mentioned above. A frequent form, where the dilatation has involved the major calices, and the minor calices empty into a large common pouch, is well illustrated in Figs. 138, 139 and 140.

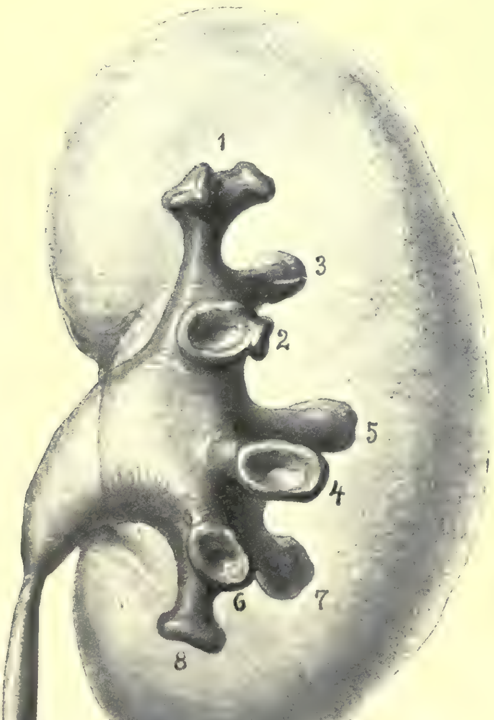

Fig. 139.—Shows the same kidney as in Fig. 138. Anterior view. (Brödel.)

Fig. 140.—Lateral view of same kidney as the two preceding figures. (Brödel.)

Bloodvessels.—The renal artery, coming from the aorta, runs behind the renal vein and in front of the ureter or ureteropelvic junction. On reaching the hilus, branches are given off which are arranged within the renal sinus into a dorsal and ventral group, the dorsal vessels lying behind, and the ventral ones in front of the branches of of the pelvis. On entering the substance of the kidney, the larger arteries lie between the pyramids as the arteriæ interlobares. Dividing, they then pass transversely across the bases of the pyramids in the form of arches. These in turn give off numerous branches,

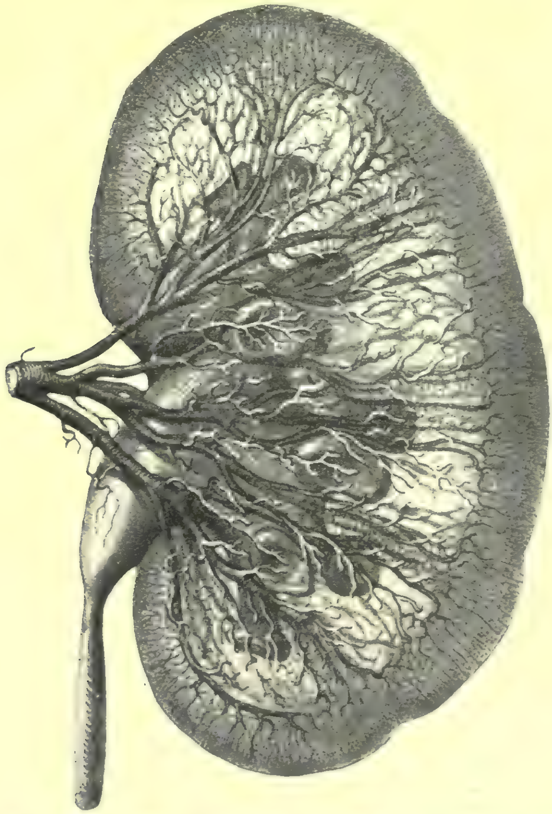

FIG. 141.—The renal artery and the distribution of its branches in relation to the pelvis. Anterior view of a left kidney. There are six main branches seen entering the kidney substance. Only one of these (the third) passes posterior to the pelvis at the hilum, also small arteries coming from the upper and lower main branches are seen to pass posterior to the upper and lower calices. All the rest of the arteries pass anterior to the pelvis and its calices. The small branches to the cortex of the anterior portion of the kidney have not been drawn in order that the large branches and the pelvis might appear more distinctly. (Brödel.)

FIG. 142.—Transverse section through the middle of the same kidney seen from above. The anterior branch of the artery supplies about three-fourths of the kidney substance while the posterior branch supples only one-fourth. The dotted line and arrow indicate the plane of arterial division. (Brödel.)

running toward the periphery in the pars convoluta of the cortex, which are called the arteriæ interlobulares. From these run short branches each forming the afferent vessel of a glomerulus, where they break up into the well-known glomerular, capillary tuft (Figs. 141 and 142). A vessel of smaller calibre than the entering one leaves the glomerulus as vas aberrans. This again divides into capillaries and surrounds the tubules of the cortex, convoluted and straight. The tubules of

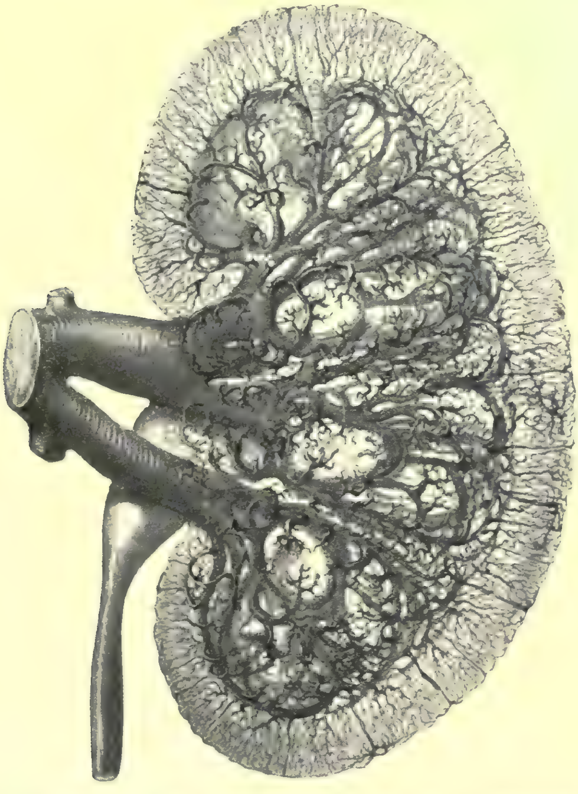

Fig. 143.—The renal vein and the relation of its branches to the pelvis of the kidney. Anterior view of the left kidney. For the sake of clearness the small veins of the cortex of the anterior portion of the kidney have been omitted. (Brödel.)

the pyramids are also supplied by capillaries coming from efferent glomerular vessels, called in this region the arteriolæ rectæ. A number of branches of the interlobular arteries supply the fibrous capsule of the kidney, and anastomose with capillaries in the fatty capsule.

The veins run a course similar to that of the arteries. Arising as capillaries, they unite at the bases of the pyramids in the form of arches, which send branches to the sinus renalis arranged into dorsal and ventral groups (Figs. 143 and 144). These in turn unite in the renal vein

going to the vena cava inferior. Certain groups of venous capillaries lying close beneath the capsule converge to form a larger single radicle which also passes inward to join the arches at the bases of the pyramids. From their form these groups of capillaries are called the stellate veins of the cortex.

Lymphatics.—The kidney is richly supplied with lymphatics. The superficial group, forming a plexus in the fibrous capsule, penetrates the organ to join the deep system of lymphatic channels whence both pass from the organ at the hilus together with the bloodvessels. Besides these, there exists a network of freely communicating lymph spaces about and between the tubules.

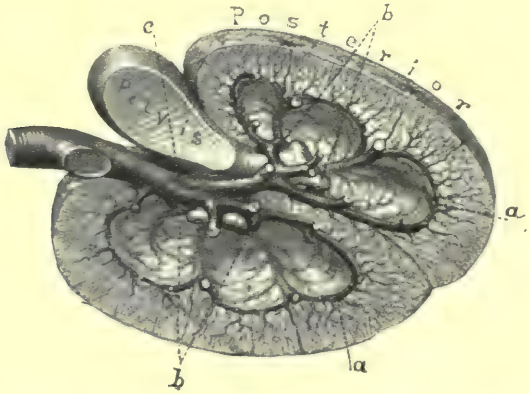

FIG. 144.—Transverse section seen from above. There is no collecting vein posterior to the pelvic; all the veins of the posterior region cross over to the anterior portion between the necks of the minor calices (*b*) to join the veins of the anterior region at a point indicated by *c*. (Brödel.)

Microscopic Anatomy.*—The elements of the kidney whose microscopic structure is of importance are the following: The glomerular tuft of capillaries (Malpighian body) enclosed within the blind end of the pouch forming Bowman's capsule; the proximal convoluted tubule; Henle's loop, with descending and ascending limbs; the distal convoluted tubule; the junctional tubule; and finally the collecting tubules emptying into the calices and pelvis.

The structure of the wall of the tuft of bloodvessels making up the glomerulus is that of a single layer of capillary endothelium (Fig. 145). The afferent and smaller efferent vessels join the tuft in close proximity to each other. About this Malpighian corpuscle are thrown the two layers of Bowman's capsule which is also made up of a single layer of flat cells. The capsule goes over into the convoluted tubule abruptly at a point about opposite the vascular hilus (Fig. 146).

* The normal histology of the kidney is a subject familiar to every student, so that only a most brief outline will be given here.

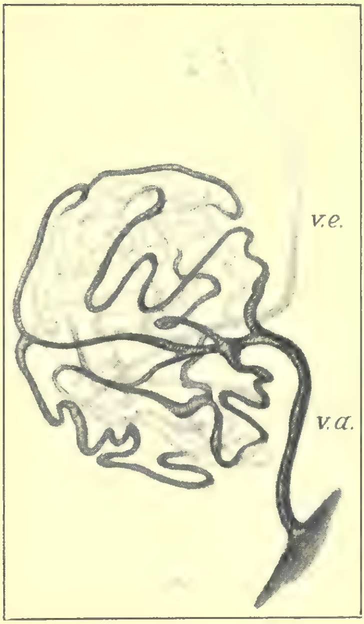

FIG. 145.—Drawing of a glomerulus from an injected specimen: *v.a.*, vas afferens; *v.e.*, vas efferens. Note larger size of afferent vessel. (After Krause.)

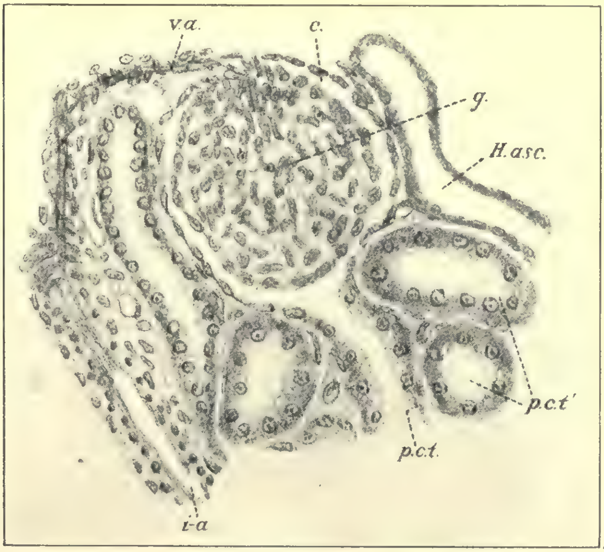

FIG. 146.—Section of the cortex of the kidney: *c.*, Bowman's capsule surrounding glomerulus (*g.*) and going over into the proximal convoluted tubule (*p.c.t.*); *v.a.*, vas afferens; *i.a.*, interlobular artery; *p.c.t.'*, proximal convoluted tubule cut in cross-section; *H. asc.*, ascending loop of Henle tubule. (After Krause.)

The epithelium of the proximal convoluted tubules is of cuboidal form, surrounding a rather small lumen. The cells have no distinct

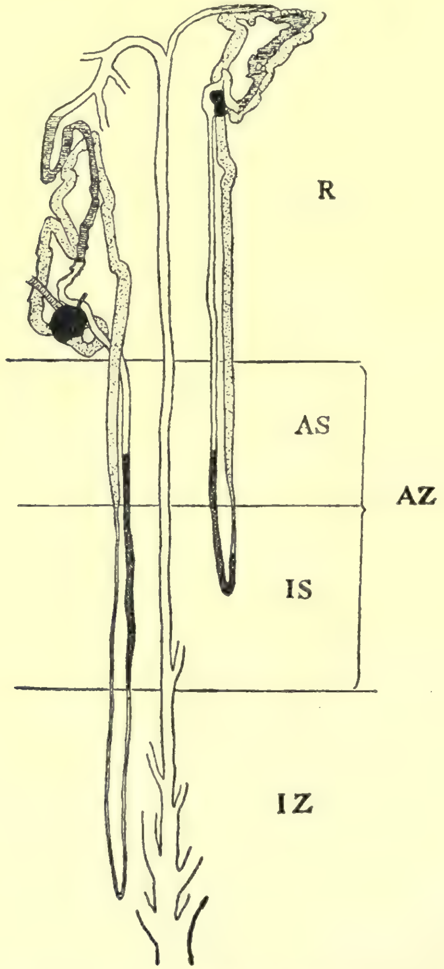

FIG. 147.—Scheme of course of renal tubule of mammalia: *AS*, outer stripe; *IS*, inner stripe; *AZ*, outer zone; *IZ*, inner zone; *R*, cortex, black, renal corpuscle; stippled, proximal convoluted portion with medullary segment (Hauptstück); cross-lined, intermediate segment (eigentliches Schaltstück), distal convoluted portion; cross-hatching, thicker, darker part of Henle's loop; clear lighter, thinner part of Henle's loop, part of distal convoluted portion (Zwischenstück) and collecting tubule. (After Peter.)

boundaries separating them from each other. The basally situated, deeply staining, nucleus is round, and the protoplasm granular. According to the state of activity of the cell when fixed, it shows more

or less vacuolization, or even a brush-like or cilia-like formation on that side of the cell bordering on the lumen.

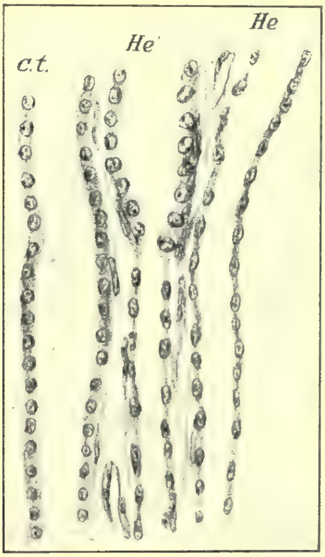

FIG. 148.—Section to show straight tubules of kidney: *He*, Henle loop, descending limb; *He'*, Henle loop, ascending limb showing abrupt change in size of lumen and of cells; *C.t.*, collecting tubule. (After Krause, Normal Histology, Tr. Schmahl, New York, 1913.)

FIG. 149.—Section through the medulla of kidney, showing papillary ducts composed of characteristic cylindrical cells and surrounded by considerable connective tissue. (After Krause, Normal Histology, Tr. Schmahl, New York, 1913.)

At a varying distance from the glomerulus (Fig. 147) the convoluted tubule suddenly becomes narrow, and forms the descending limb of the

Henle loop. The epithelium of this tubule is low and flattened, with clear protoplasm. The nucleus is often flat, and the tubule, as seen in sections, may be very suggestive of a capillary.

The ascending limbs resemble the distal convoluted tubules somewhat, except that their cells are less tall. The cells of the distal convoluted tubules resemble those of the proximal, except that their markings are less distinct, and their size smaller. They may also have basal striations. The junctional tubules are hard to distinguish in stained sections from the portion just preceding them, their cells being about of the same character. The collecting tubules have round, well-defined lumina, and distinct cell walls. The protoplasm is clear, and the nuclei are arranged at the bases of the cells in quite regular fashion.

PHYSIOLOGY OF THE KIDNEY.

The physiological processes which underlie the production of urine for years have received much attention from both laboratory investigators and clinicians. A wealth of literature has been amassed on the subject, but because our methods of investigating the life processes of the individual cell lack much in subtlety, we are still in the dark in regard to many phases of renal activity. A sufficient number of facts to establish a working basis are known, however, and it is with these that the present remarks will deal.[4]

The kidney is classed as a true secretory gland of the compound tubular type, but it differs from all other secretory glands in the fact that the products elaborated by it are, in the man, already present in the blood coming to the organ, though to be sure, in different concentration from that in which they leave the kidney.

Theories of Renal Secretion.—The earliest theory of renal secretion is that of Bowman in 1842, and is based on the anatomical characteristics of the organ as he had discovered them in the glomerulus and its capsule. He asserted that the water of the urine was secreted by the bare tuft of capillaries in the Malpighian body, and that this, in its passage down the tubules, washed out the solid constituents which had been secreted by the cells lining these channels.

No experimental proof of this theory was brought forth till the appearance of the views of Heidenhain in 1874. He postulated for the renal cells, both of the glomerulus and tubule, a "vital activity." By means of this power the glomerulus was supposed to secrete water and salt, while the epithelium of the convoluted tubules and of the wide part of Henle's loop secrete most of the solids of the urine, such as urea, uric acid and others. These are carried out of the cell by a small amount of water, under usual circumstances, but under diuresis the increased water comes from the tubular cells and not from the glomerulus. Thus, this view considers that the glomerulus secretes a fluid very similar to lymph minus its proteid, and this in its passage

down the tubules carries along the urea, uric acid and salts secreted by their cells, thus reaching the collecting tubules as normal urine.

Two years after Bowman published his views, Ludwig proposed another theory of renal secretion. He considered the capsule to be a simple filter which allowed all the constituents of the plasma to pass except the proteids, and that this filtrate during its passage through the tubules was transformed into urine by the return of much of the fluid into the blood by a process of diffusion. This purely physical theory was soon modified by its author to include differential absorption by the tubules, instead of simple diffusion into them; for only in some such way could the differing proportion of salts as found in blood and urine be explained. Today, however, this theory has little more than historical value, for it has long been evident that purely physical forces are inadequate to explain all the factors concerned in the formation of urine.

The first theory assumes that the glomerulus acts as a filter, while the function of the epithelium of the tubules is absorption and not secretion. The second maintains that the glomerulus secretes the salts and the water of the urine, while the cells of the tubules are also secretory in nature, the substances elaborated by them being the organic constituents such as urea and uric acid. It is evident, therefore, that each theory considers the urine as the resultant of the activity of two separate areas, the glomerulus and the tubule, especially the convoluted tubule. In discussion it will be easier to follow the separate function of each of these regions.

Function of the Glomerulus.—Assuming that the glomerulus acts as a filter, the quantity of urine, in regard to its water at least, must vary directly with the pressure on the blood side of the membrane, and indirectly with that on the capsular side. By increasing the blood-pressure in the glomerular capillaries more urine should be put out. Such increase of pressure has been produced experimentally in two ways: first by raising the general systemic blood-pressure, and second, by obstructing the return flow from the kidney by partial or complete occlusion of its vein. In the first instance it is usually true that an increased general blood-pressure results in an increase in the quantity of urine. But that this increase may not be due to the pressure factor, but rather to the factor of increased blood rate, is suggested by the observation[5] that if the rate be increased without concurrent increase of pressure, the amount of urine is even then increased. This may mean that the cellular activity is greater in the presence of an increase in the amount of substances brought to it for secretion. In the second instance, however, blocking of veins causes a diminished flow, or even a cessation of the stream. The most plausible explanation of this last result is that under the conditions of impeded outflow of blood, less oxygen is brought to the capsular cell and less carbon dioxide removed. Thus there is caused an asphyxial condition which prevents normal cellular activity. Such

findings are strongly against the filtration theory; for did the glomerulus act in this way, damage to its wall would be expected to render it more permeable rather than less so. Similarly also, temporary closure of a renal artery causes anuria, which may persist for some time after reëstablishment of the circulation. This can only mean a suspension of intrinsic cellular activity caused by lack of nutritive substances brought by the blood.

Experiments to show the result of raising the pressure on the capsular side of the glomerular membrane have been made by occluding the ureter. Under these conditions the pressure in the ureter and kidney pelvis rises to about fifty to sixty millimeters of mercury, where it stays. This fact might be interpreted to mean that the pressure on either side of the filtering membrane had become equalized, and that because of this the production of urine had stopped. This would tend to support the mechanical theory. But it is also possible that under these conditions urine may still be formed, only to be absorbed again owing to the high pressure in the tubules. This latter explanation seems the more probable, and is further supported by observations which show[2] that if the ureter be only partially occluded the quantity of urine is increased instead of diminished.

In view of the above evidence it seems clear that any theory which considers the glomerulus to act as a simple filter must be discarded. Three other methods of action are open for discussion: secretion, ultrafiltration and osmosis. The older observers were forced to accept the theory of active secretion by the glomerulus if they denied that of filtration, although proof of such secretion was hard to bring forward. The main difficulty lay in the fact that the morphology of the glomerulus cell is entirely unlike that of any other cell in the body which is known to be of secretory nature. Not all its cells are of the same character, however, and it must be acknowledged that a theory of function based on morphology alone is always very insecure.

In the light of our newer knowledge along physical lines it seems much easier to explain the glomerular function than heretofore. The mechanical conditions present are entirely such as would make the occurrence of osmotic phenomena most probable. By regarding the capillary layer of Bowman's capsule as a semipermeable membrane separating fluids of differing concentration, we create a situation most favorable for osmosis. As has been noted above, the efferent vessel from the glomerulus is narrower than the afferent. This makes the stream slower. It probably does not increase pressure in the glomerular tuft, however, owing to the rapid expansion of the blood bed in the numerous capillaries. No very reliable estimations of the blood-pressure in the glomerular capillaries have been possible, but it would seem to be quite low under normal conditions. If this be true, the removal from the blood of crystalloids or colloids seems improbable from lack of pressure; and furthermore, if we grant that osmosis takes place the assumption of ultrafiltration also, is an unnecessary one.

In brief, the theory of Ludwig that the glomerulus separates from the blood all of its constituents except albumin is probably true if we add that it does this by osmosis and not by filtration.

Function of the Tubules.—The function of the convoluted tubules is of equal importance with that of the glomerulus. The types of cells found in the proximal and distal convoluted tubules have already been described. In their microscopic appearances they are typical secreting cells, and that they do so secrete has been widely held.

Numerous observations have been advanced to show the secretory properties of these cells, the most conclusive being the demonstration of the constant presence of secretion granules and vacuoles. They also contain numerous mitochondria, though what the exact significance of such structures may be is not yet entirely clear. The weight of opinion is that they are evidences of secretory activity, however. Furthermore, substances of one sort or another, after injection into the circulation, have been found in these cells, and in none others. In this way indigocarmin has been used by Heidenhain, and neutral red by Cohnheim. Again, specific stains, as those for uric acid and iron seem to show that the convoluted tubule cell is the point of exit for these substances from the kidney.

On the other hand, the question as to whether these cells have an absorptive power is of great importance, and in view of the careful observations of recent years along the lines of physical chemistry, can hardly be denied. If one assume that the glomerulus prepares a urine corresponding to the blood except for its proteid content, then absorption of water, at least, by the tubules is a necessary corollary of this assumption, because certain substances are found in the urine in marked concentration over that which they possess in the blood, as for instance is the case with urea. As a matter of fact all the most recent work tends to prove that besides water, certain salts necessary to the organism are absorbed by the tubules, while other salts not needed are allowed to pass.

By far the best summary of the present opinions regarding these questions is presented by Cushny in his recent masterly monograph.[4] After pointing out the inadequacy of the previous theories of the secretion of urine, he advances in their stead the so-called "modern theory." This theory holds in brief that the function of the kidney is performed by the filtration of the non-colloid constituents of the blood through the capsule, followed by the absorption of a fluid of unvarying composition very similar to Locke's solution through the cells of the tubules. "The capsule furnishes the tubules with the fluid as it exists in the circulation, the tubules return to the blood the fluid best adapted for the tissues, and allow the rest to escape in the urine. Thus if the plasma is too rich in sugar or chloride, the filtrate also contains it above the threshold value; the epithelium, however, returns it at the optimal or threshold concentration and the remainder passes into the ureters. If much water has been ingested and the

filtrate is correspondingly dilute, the subtraction of the optimal solution leaves the excess of water in the urine along with the urea and other waste products. The formation of the glomerular filtrate is due to a blind physical force, the absorption in the tubules is equally independent of any discrimination, for the fluid absorbed is always the same, whatever the needs of the organism at the moment."

The Action of Diuretics.—Diuretic substances brought to the kidney by the blood may cause an increased flow of urine by various methods of action. Many drugs, for example, which cause an increase in the general blood-pressure will cause diuresis also. In this case the diuretic action is supposed to be the result of the increased amount of blood passing through the organ in a given time unit, rather than of the increased pressure as such. Other substances, however, cause diuresis without an accompanying increase of pressure. Such findings have led to the classification of diuretics into two groups. For a measure of the renal metabolism the consumption of oxygen has been determined by comparison of the blood in the renal artery and renal vein.[1] This done, diuretic substances are found to be either of the first type which act without causing alteration in the gaseous exchange of the kidney, the main exponents of this group being Ringer's solution, and sodium chloride in hyper- and hypotonic solutions; or of the second type, all of which cause diuresis together with an increased gaseous exchange. Such substances are urea, caffein, sodium sulphate and phloridzin. So we conclude that some diuretics cause a true secretion, while others cause an increase in the urinary output by physical means.

The Innervation of the Kidney.—The influence of the nervous system on the kidney is seen mostly as a secondary one, acting through the vasomotor fibers on the bloodvessels. It has been shown definitely that the kidney is able to act entirely normally when freed from all its nerves.[7] So that for its function it depends more on the chemical properties of the blood, while the nervous system plays a secondary, regulating role. The presence of secretory fibers to the kidney has been the subject of much investigation, but up to the present no accepted evidence has been brought forward of the existence of such. Under various circumstances, however, action of the nervous system on the kidney may be seen clinically, and this may be shown by change in the urinary composition or in its quantity. Polyuria is often seen as a result of central nervous stimuli. Such instances are found in cases of brain disease such as migraine, concussion, fractures or tumors. The nervous polyuria of diabetes insipidus, when an accompaniment of changes in the hypophysis, also falls in this group. It is not yet quite clear that polyuria can be caused by peripheral stimuli, although most evidence points in this direction. The polyuria coming from the untreated side during the passage of a ureteral catheter on the other suggests an intrarenal reflex, as does also the polyuria sometimes seen in cases of high ureteral obstruction due to stone.

That anuria can be caused by stimuli from the central nervous system does not seem surely proved, although the inhibition of kidney function seen in many cases of hysteria is often quoted as of this origin. It is certain, however, that by stimulation of the peripheral urinary passages, as well as unilateral renal disease, a complete anuria can occur. In urological literature there are found two kinds of reflex anuria, the peripheral and the renal forms. The first has been seen after ureteral catheterization, after artificial overstretching and sudden emptying of the bladder, after instillation of marked irritants, and accompanying phimosis in the newborn. The second, or renal form, has followed stone in only one ureter, or other mechanical obstruction, or after operation on one kidney in the presence of a presumably sound organ on the other side.

Alterations in the composition of the urine caused by stimuli from the central nervous system are seen in such cases as those albuminurias following epileptic attacks. That these are not due to the convulsion is shown by the fact that they also are found in attacks of *petit mal*. Besides this, the well-known observations of Claude Bernard have demonstrated an area in the floor of the fourth ventricle, lesions of which cause a glycosuria. These findings have been further extended by Eckhard[3] who has been able to cause changes in the sodium chloride content of the urine of one kidney over that of the other through injury of cerebral areas nearby those causing the appearance of sugar. These phenomena appear in the kidney contralateral to the medullary injury; and for this action the integrity of the splanchnics is necessary. There is therefore a crossing of the pathways from the higher centres to the kidney.

Anatomically we have evidence to show that the nerves to the kidneys come from the splanchnics, major and minor, and from the vagus. Each group enters the celiac ganglion, whence branches go to the hilus of the organ along the vessels. The splanchnic fibers run upward through the cord to reach the midbrain. Both in the periphery at the ganglion, as well as in the cord, there is connection with each side, either by anastomosing fibers or by direct crossing. There are also ganglionic cells in the kidney itself; so that we find central or preganglionic, postganglionic, and intrarenal neuronal complexes. But we must again emphasize the statement made above, that except for the action of the vasomotor system on the kidney, its nerve supply seems to play a role entirely secondary under normal conditions of life.

The Composition of the Urine.*—The urine is a clear, homogeneous fluid, containing in solution salts, and many organic products of bodily metabolism. Its color varies from light straw to reddish brown, according to the amount of water ingested and the external temperature.

* No attempt is here made to give a detailed account of the chemical and physical properties of the urine. For these the reader is referred to the many works on urinalysis.

It has an aromatic odor, depending directly on what has been eaten. The specific gravity varies from 1002 to 1040; the average being 1017 to 1020. The reaction is usually acid, but since this depends on the substances in solution, the reaction may be either neutral or alkaline. The average daily quantity is about 1500 cubic centimeters, holding about 60 grams of solids in solution. Though it varies greatly, the average daily composition is made up as follows:

Inorganic Matter.		Organic Matter.	
NaCl	15.0 gm.	Urea	30.0 gm.
H_2SO_4	2.5 "	Uric acid	0.7 "
P_2O_5	2.5 "	Creatinin	1.0 "
K_2O	3.3 "	Hippuric acid	0.7 "
NH_3	0.7 "	Other substances	2.6 "
MgO	0.5 "		
CaO	0.3 "		
Other substances	0.2 "		

Sugar and albumin, though present in the blood, are not normal in the urine except in the most minute traces, so small as to be detected only by the most delicate chemical methods. Some mucus, and such formed elements as an occasional squamous cell, or small round epithelial cell from the urinary passages, are also normally present.

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CHAPTER X.

TESTS OF RENAL FUNCTION.

By JOHN T. GERAGHTY, M.D.

Having become more or less familiar with the gross and microscopic pathology of diseased organs, the physician today is also interested in knowing to what extent disease had interfered with the function of any particular organ. Having learned that the organ is diseased, it becomes of great importance to know to what extent the functions of the organs are interfered with. The kidney, on account of the readiness with which its secretion can be obtained, has lent itself admirably to the development of functional studies, and, as a consequence, tests have been evolved which reveal in a remarkably accurate manner the function of that organ.

The failure of routine chemical and microscopic methods of examination of the urine, together with the data obtained from a clinical study of the patient to reveal the true extent of the renal disorder, is a matter of common knowledge. Albumin and casts may be absent from the urine in cases of severe renal disease, while they may be present when no serious involvement of the kidney itself exists, but where the kidney is simply suffering secondary to disturbances going on elsewhere in the body. An attempt to surmount this difficulty has been made by introducing quantitative estimation of the excretion of the normal urinary constituents, such as urea, chlorides, phosphates, total nitrogen, etc., but this has proved disappointing because of the fact that the amount of these substances excreted depends not only on the functional activity of the kidney, but upon the amount of the substances conveyed to the kidney for excretion. In order to make the data concerning the excretion of these substances of any true value it is necessary to know the intake of salts, proteids, etc.; in other words, it is necessary to undertake extensive metabolic studies. Even such studies have often failed to furnish the information desired.

FUNCTION OF THE KIDNEY IN HEALTH.

To separate from the blood the substances carried to it for elimination and to pass these substances on to the urine constitute the chief function of the kidneys, but the exact nature of the processes by which this end is accomplished has been and is at the present time more a question of speculation and theory than a matter of actual conclusive demonstration. Certain phenomena are recognized in connection with the execution of the renal function, the examination and estimation of

which under normal and under diseased conditions apparently throw light on the method as well as on the efficiency with which the kidney carries on its work. The kidney separates from the blood the urine, a fluid of different molecular concentration, which process, according to Ludwig, involves filtration and osmosis. An estimation of the work performed can be readily made by comparative study of these two fluids by means of cryoscopy. The kidney exerts, according to the Bowman-Hiedenhain theory, selective absorption on certain substances brought to it and the amount of this substance absorbed and excreted in the urine can be estimated. The kidney is also capable of synthetizing the hippuric acid from the glycocol and benzoic acid, and quantitative estimations of this glandular activity is readily obtained. A control over nitrogenous metabolism by means of an internal secretion has been suggested, but no positive proof of its existence has so far been brought forward. The work of Ludwig showed that in animals the work done by each kidney separately varied considerably at any given time, but later investigations by Kaspar and Richter, following the introduction of the ureteral catheter, seemed to indicate that this did not hold for the human subject and that both kidneys apparently did the same amount of work at any given time. The more careful work of Albarran and Kapsammer showed the fallacy of these earlier investigations and definitely established that differences do exist in the amount of work done at any given time if the observations are maintained for only short periods of time, but that if the experiment is continued over longer periods the differences become less marked. Albarran has shown that when the experiment lasted only fifteen minutes the difference might amount to 30 per cent., but if the experiment was prolonged for an hour the difference decreased to only 10 per cent. Likewise, the difference in the amount of the urea, chlorides, and phosphates from the two kidneys diminishes as the time of observation is extended. In the course of ten to twelve hours both kidneys do practically the same amount of work.

FUNCTION OF THE KIDNEY IN DISEASE.

With the occurrence of disease in the kidney, changes in its function become manifest. The nature of these changes varies greatly, depending on the pathological processes at work, and these changes in function may be associated with or totally independent of any anatomical variation, macroscopic or microscopic, demonstrable. We know that marked disturbances in function are not necessarily associated with anatomical changes. On the other hand, demonstrable anatomical changes do not necessarily mean changes in function. In the majority of instances of disease there occur in the urine changes which are readily detected by the ordinary routine chemical and microscopic examination, and which, considered together with the history, symptom-complex, and physical examination, easily lead to the recog-

nition of the disease. Quantitative estimation of the substances present in the urine, whether normal or abnormal, is frequently employed not only to obtain a better knowledge of the physiological pathology of the disease, but to obtain also an indication of the severity of pathological process. Quantitative metabolic studies can be carried on, however, only under exceptional conditions, and do not even then always furnish the information desired, as has been shown by von Noorden. These studies are also beyond the time, facilities, and training of the average physician. It becomes evident, therefore, that other methods of investigating the functional activity and efficiency of the kidneys are desirable and necessary.

The Ideal Functional Test.—Owing to the large number of functional tests that have been brought forward in late years, it becomes advisable to consider what requirements can be demanded of such a test. These are, as their name implies, simply means of estimating the functional activity of the kidney, and because of our lack of knowledge of the biochemical activity of the kidney these tests can only have an empirical value. The failure of the kidneys to excrete phthalein does not tell us the cause of this failure. Functional tests consequently must be used not alone, but only in conjunction with and in relation to a thorough clinical investigation of the patient's condition: (1) Such a test should indicate within narrow limits the constant amount of work performed by all normal kidneys under normal conditions; (2) it should indicate constant variations in function when constant abnormal conditions are present; (3) it should indicate functional alterations independent of histological appearance when such conditions exist; (4) it should afford an indication of the absolute work accomplished as well as the relation of this to the normal standard under all conditions; (5) it should be applicable with as simple technic as possible; (6) it should be applicable without injury to the patient or without exerting extrafunctional calls or strain upon the kidney itself; (7) the method itself should be mathematically accurate; (8) the result of its application should be easy of interpretation; (9) it should not only be capable of indicating the work executed under normal conditions, but should also be capable of revealing the latent or reserve force which can be utilized by the kidney under strain. That it is possible to estimate the work performed by the kidney in any particular phase of this function has been indicated. An extensive study from any aspect of the work performed reveals the fact that in health the kidney will perform so much work within certain narrow limits. This fact makes it possible to establish certain definite standards of work for the kidney to which all normal kidneys under normal circumstances will conform. Knowing the standards of work for a normal kidney, naturally the work performed by the diseased kidneys has been estimated and a comparison made of this work with that of the standard. In this way functional tests have originated, developed, and multiplied.

The earliest observations of the variation and limitations of the kidney in disease were those of Hahn, who noted the absence of the odor of violets in the urine of gouty subjects after the ingestion of turpentine, and of Rayer, who noted the absence in nephritis of that peculiar odor which normally is present in the urine after eating asparagus. It is possible that the functional test originated from the study of the faulty excretions of drugs, giving rise to evidences of toxicity in certain diseases of the kidney. Various investigators published accounts of the retardation in the excretion of the various drugs, among which may be mentioned Dover's powder, mercury, iodides, alkaline carbonates, salts of potassium and sodium, quinin and salicylic acid. In 1877 Bouchard conceived the idea of using fuchsin for estimation of the power of excretion of the kidney, but little was really accomplished until twenty years later, when Achard and Castaigne introduced methylene blue into this field and conclusively demonstrated the possibilities of this method of attacking the problem.

Renal functional tests, as employed at the present time fall into two groups: (1) Tests of retention, namely, an estimation of the variation of substances normally present in the blood in fairly constant amount in health; (2) tests of excretion, namely, estimation in the urine of the amount of certain substances normally present or the amount of a foreign substance, a known amount of which has been administered; (3) combination of the tests of retention and excretion.

Again, tests can be subdivided into those which attempt to determine total function and those attempting to differentiate between tubular and glomerular activity. The test for hippuric acid in the urine following the ingestion of glycocol and benzoic acid is unique, and differs from all others in that this substance is formed in the kidney itself and indicates glandular activity. Achard and Chapelle amended this test, but it has never been employed for its functional value.

TESTS OF EXCRETION.

Dyestuffs.—Methylene Blue.—Methylene blue first was introduced in 1897 by Achard and Castaigne. The drug may be given by mouth in $\frac{1}{4}$-grain doses, but is usually administered by intramuscular injections, 15 minims of a 5 per cent. solution. In health the drug appears in the urine in about fifteen minutes as a chromogen, the presence of which is easily demonstrated by boiling after the addition of a little acetic acid. At the end of a half-hour the dye begins to appear as such in the urine. The excretion of methylene blue continues in both forms for from thirty-six to forty-eight hours, and in some instances as long as six days even in health. The important phenomena to be noted are:

1. Time of appearance of the drug.
2. The time of the maximum intensity of the excretion.
3. The time required for a total elimination of the drug.

Achard and Castaigne pointed out that the time of appearance is delayed, as is also the time of maximum excretion, and that the duration of the excretion is much prolonged in disease of the kidneys. This has been confirmed by Müller and various workers. In chronic interstitial nephritis the secretion is very slow, sometimes being prolonged for as long as fifteen days, and excretion of the dye is not even and continuous, but may assume different types or curves of excretion, as described by Chauffard and by Chauffard and Cavasse. Bard and Bard and Bonnett have called attention to the fact that the excretion is not delayed in all forms of disease of the kidney, but that it is usually normal or even accelerated in acute or chronic parenchymatous nephritis. It has been shown that the excretion of methylene blue in health and disease runs more or less parallel with various other drugs (iodides, salicylates, indigo-carmine, and rosanilin) and that a decreased or increased elimination for one indicates the same condition for other drugs. In this connection Bard and Bonnett called attention to one exception. In chronic parenchymatous nephritis associated with secondary sclerosis there exists a diminished permeability for iodides, while the permeability for methylene blue is normal or exaggerated.

Quantitative estimation of the amount of drug excreted by the kidney has been attempted by the following technic: Before administration of the drug the urine is collected for some time and set aside. The drug is then administered and the urine collected for as long a period as desired, all the chromogen being converted into dye. An equal quantity of the urine previously collected is then taken, and to it is added through a burette, drop by drop, a sufficient quantity of a solution of methylene blue of known strength to bring the color of the two urines to exactly the same intensity of color. The colors are compared by placing the two tubes side by side against a white background. In this way fairly accurate estimations can be obtained, but occasionally the variation in the quality of the color is so marked that a quantitative estimation is impossible.

Walker has shown that in obstruction of the lower urinary tract the excretion of methylene blue is retarded. In hypertrophy of the prostate the dye frequently does not appear for three or four hours, and is then excreted for a period of eight to ten days following injection. In several instances it did not appear at all.

Underhill and Closson have shown that methylene blue is not a chemical entity, but is a mixture of methylene blue and methylene azure. The appearance of the drug in the form of a chromogen necessitates additional manipulation when readings are being made, and affords an opening for speculation and difference of opinion and doubt as to the interpretations of the findings. Chauffard and Cavasse considered that some significance is attached to the amount of chromogen and the amount of dye excreted. Methylene blue is painful when given subcutaneously, and is frequently followed by some pain even

after intramuscular injection. It is very slow in appearing in the urine, and the time of elimination is very prolonged, necessitating a long period of observation and a large number of examinations of the urine. The color of the dye as excreted is readily influenced by the color of the urine and does not lend itself well to colorimetric methods of estimation. The drug undergoes unknown chemical changes in the body, only a part (50 per cent.) being normally excreted in the urine. Occasionally it is completely destroyed in the body even in health, and cannot be demonstrated at all in the urine, as has been described by Pugnat and Revilliod, Walker and others.

This test is cumbersome and, comparatively speaking, rough, yet Walker claims that to him it has proved of more value than the quantitative estimation of the urea or the appearance of general symptoms of renal inadequacy.

Indigo-carmine.—This substance was first used by Heidenhain in his well-known investigation of physiology of the kidneys. He was able to show that the epithelial cells of the convoluted tubules were the portions of the kidney substance which excreted this dye. In 1903 Voelcker and Joseph proposed the use of the dye for purposes of testing the renal function. The method of performing the test is as follows:

A 0.4 per cent. solution is used and 20 c.c. of this is injected into the muscles of the gluteal region. The drug has also been given intravenously. If stronger preparations are used the indigo-carmine does not remain in solution but exists in the form of a fine suspension. A sufficient quantity must be used to give a deep greenish blue when a good elimination occurs. According to Kapsammer excretion is complete in twenty-four hours, on an average, in healthy individuals, although considerable variations exist. Walker states that practical elimination occurs in twelve hours. In disease of the kidneys the appearance is delayed and elimination prolonged. Quantitative estimations have been attempted, methods similar to those employed in estimating methylene blue being used. Oppenheimer attempted to use the Doboscq colorimeter, but found the color of the drug did not lend itself to colorimetric reading on account of the variations in quality produced by the coloring matter of the urine. When a large quantity of indigo-carmine is injected some is excreted by the liver and appears in the feces as a leucoderivative. When ordinary doses are used, not more than 25 per cent. of the drug is excreted by the kidneys. The fate of the remainder of the substance is not known. Indigo-carmine seems more valuable than methylene blue for the purpose of functional tests on account of its more rapid appearance and quicker elimination. The test is still enthusiastically advocated by some men, notably Thomas. To us the main value of indigo-carmine is its employment to indicate the situation of the ureters in cases in which ureteral catheterization is difficult. In certain instances in which it is impossible to catheterize the ureters, information regard-

ing the excretion of the dye can be obtained by watching the density of the urine ejected from the ureteral orifices. Valuable information at times may be obtained, and the drug has a very definite field of usefulness. For accurate estimation of renal function its position has been superseded.

Rosaniline (Sodium Rosaniline Trisulphate).—Rosaniline was first introduced by Lepine. The technic of the test is as follows:

One c.c. of a 1 per cent. solution is injected subcutaneously or intramuscularly. This practically always appears in the urine in normal cases in less than a half-hour. He found that the maximum intensity of color occurred during the second hour in some cases, but more frequently during the third hour. Total elimination is usually over in twenty-four hours; occasionally it is complete in twenty hours. The curve of excretion is marked by a rapid ascent, a plateau more or less long, and a slowly progressive descent. The curve is essentially monocyclic as contrasted with the polycyclism of methylene blue. The quantity eliminated varies from 65 per cent. to 95 per cent. In acute and parenchymatous nephritis the drug appears as early as in normal cases, and the quantity eliminated varies between 27 per cent. and 50 per cent. In interstitial nephritis the appearance of the drug is delayed and the time of elimination is markedly prolonged. Dreyfus found that the excretion of rosaniline is normal in cases of pure albuminuria. Quantitative estimations have been made by methods similar to those employed for estimating the excretion of methylene blue and indigo-carmine. The urine must be made definitely acid in order to bring out the full intensity of color. Rosaniline would seem to have many advantages over other dye substances used for functional tests; its greatest advantage would seem to be its almost entire elimination by the kidneys. The test, however, has not obtained any popularity.

Phloridzin.—Von Mering's discovery of that peculiar property of phloridzin by virtue of which it produces a glycosuria unaccompanied by hyperglycemia was not utilized practically for many years. In 1896 Klemperer used this drug in order to prove the possibility of the existence of a condition of renal diabetes. He observed at this time that the glycosuria was absent in cases of advanced chronic interstitial nephritis, which involved him in a controversy on this point with Magnus Levy. Klemperer administered the drug by mouth while Levy used it subcutaneously, both using immense doses. Achard and Delamere subsequently showed that these large doses were unnecessary and that small doses would produce a glycosuria. They studied the influence of phloridzin in a large series of cases and found generally a diminution or total absence of glycosuria in kidney disease. They also showed that in acute or subacute nephritis the glycosuria was frequently absent when the excretion of methylene blue was normal or even increased.

Phloridzin was used to show the functional activity of the kidney

from the stand-point of its glandular function, and therefore thought to differ from all the other tests. The trend of recent work, however, tends to show that the phloridzin does not stimulate the kidney to synthetize sugar but that its action is to increase the permeability of the kidney for the excretion of the sugar. It has been known quite definitely that the quantity of sugar excreted in normal individuals following the injection of phloridzin will vary more or less directly with the intake of carbohydrates.

The test consists in the subcutaneous administration of 5 to 10 mg. of a freshly prepared solution of phloridzin. This is followed in normal cases in from twenty minutes to a half-hour by the appearance of sugar in the urine. The glycosuria increases in intensity and reaches its maximum at the end of an hour, and then gradually diminishes, disappearing in from two to three hours. Normally 1 or 2 grams are excreted during the test.

It is customary to estimate the sugar output at fifteen-minute intervals and thus the curve of elimination is obtained.

In the presence of renal disease the glycosuria is either entirely absent or delayed in appearance, slower in reaching a maximum, and the amount eliminated is decreased.

Although formerly the test attained considerable popularity, at present it is not so generally used on account of the unreliable results it has furnished.

It has been repeatedly shown that no glycosuria has followed the injection even when it was administered to perfectly normal individuals (Walker). It is too sensitive to slight renal changes and frequently furnishes an exaggerated idea of the extent of the renal lesion.

Solutions of phloridzin rapidly deteriorate and only fresh solutions can be utilized.

The test is probably less reliable than many of the other tests used for the same purpose.

Potassium Iodide.—The excretion of potassium iodide has been utilized as a test of functional activity of the kidneys from time to time by many workers. The evidence furnished by the test, however, is unreliable and the information gained by its application is usually of comparatively little value. When administered by mouth, subcutaneously, or intravenously about 70 per cent. is excreted by the kidneys unchanged. It appears in the urine in about fifteen minutes and about 50 per cent. of the drug is excreted in the first twelve hours. The complete excretion is usually over in from thirty to sixty hours.

Lactose.—The lactose test was popularized by Schlayer and his colleagues and considered by them to be a test of glomerular function. Experimental work, however, shows that lactose is not entirely excreted by the glomeruli, but the tubules also take part in its excretion; therefore it cannot be used as a differential test between the glomerular and tubular function. The test has considerable prognostic value. The technic consists in the intravenous injection of 20 c.c. of a 10 per

cent. solution freshly prepared in distilled water and pasteurized for four hours on four successive days. Normally the lactose should be excreted in from four to six hours. Delayed excretion beyond this time indicates impairment of renal function.

The lactose test was employed by Rowntree and the writer in a considerable series of cases, with obstruction in the lower urinary tract. The lactose test in this type of case proves of but little value from a diagnostic stand-point and of no value in relation to prognosis. Repeatedly following the injection of lactose, sugar failed to appear in the urine. In some of these cases the other excretory tests showed a moderate impairment only of renal function. The failure on the part of the lactose to appear in the urine is in keeping with our earlier experiences with phloridzin in this type of renal disease. Phloridzin was used in a series of patients suffering from renal changes secondary to prostate hypertrophy, but in not a single instance was sugar recovered.

Diastase.—The diastase test was introduced into functional renal work by Wohlgemuth[14] for determining the relative functional capacity of the two kidneys. The original technic of Wohlgemuth is as follows:

After neutralization the same amount of urine from each side is placed by means of an accurately graduated pipette in a series of twelve test-tubes in amounts decreasing from 0.6 c.c., 0.5 to 0.1 to 0.04 c.c. A sufficient quantity of 1 per cent. NACl solution is then added to bring the amount of fluid in each tube up to 1 c.c.* To each tube is added 2 c.c. of a $\frac{1}{100}$ solution of freshly prepared soluble starch. The tubes are immersed in a water-bath at 39° C. for thirty minutes, after which they are placed in cold water for three minutes. To each tube is added sufficient $\frac{1}{50}$ N. iodine solution to elicit a permanent color, violet or blue occurring when digestion is not complete.

The tube in each series immediately preceding incomplete digestion of the starch indicates the diastase content of that particular urine, and from this the *d* is calculated. *D* is the diastatic activity expressed as the number of cubic centimeters of 0.1 per cent. starch solution capable of being digested by 1 c.c. of the urine utilized. It might be emphasized that neutralization of the urine is important. By a slight modification of this method it is possible to make the test adaptable for determining total renal functional capacity. The diastase is of very considerable value in the majority of cases in supplying information regarding the relative function of the two kidneys. It is about equal in value to urea percentage, though in some cases it may be of even greater value than urea percentage in that it is not so readily affected by dilution. In exceptional cases where marked inhibition or excessive leakage occurs around the ureteral catheters, diastase and urea percentage may furnish most important information in con-

*One c.c. of urine was diluted to 10 c.c. and from this diluted urine the measurements of the amounts less than 0.1 c.c. were made.

junction with microscopic and clinical data. The findings of diastase and urea percentage, however, must be accepted with extreme caution, and only when total urea and quantitative determinations are impossible. As a test of total renal function the diastase, in our experience, has not proved of much value. In some cases with severe renal damage the diastase content was normal. In the majority of instances a decreased diastase activity is present, but no constant or definite relationship between the diastatic activity and the true renal function, as shown by phthalein and clinical findings, exists. When, however, the complete absence of diastase in the urine occurs it apparently indicates a bad prognosis. The diastase test, while exceedingly simple, is time-consuming, and, furthermore, freshly prepared soluble starch solution is needed anew each day, and at least one-half hour actual time is necessary in each test.

Polyuria.—Test of Total Function.—The polyuria tests are evidently tests of variation of function, and they are applied with reference to total or to separate comparative function of the two sides. Studies in the water intake and output with reference to total function have been carried out in various ways. Strauss advises the following technic in carrying out the test:

The night urine he collected at 10 P.M. and 5 A.M.; then gave 600 c.c. of water at 6 A.M. and then made hourly collections from then until 11 A.M., and the amounts, sodium chloride, and freezing-point were determined for each specimen. Almost the same information can be obtained, however, by taking the specific gravity of the urine. The test is really a measure of the concentrating power of the kidneys. When the kidneys are diseased the concentrating power of the kidneys is decreased and the water test brings out to what extent this concentrating power is interfered with. When the concentrating power of the kidneys is seriously injured the specific gravity of the urine is low and varies but slightly in twenty-four hours, regardless of the water intake. The less the variation, the more severe, as a rule, the damage. With a normal urinary output for the twenty-four hours and a concentration varying with the water intake the kidneys can then only be assumed to be practically normal. This test is unquestionably of considerable value in estimating renal functional derangement, and it is probably one of the simplest of all tests and also easy of interpretation.

The Polyuria Test with Ureteral Catheterization.—Albarran in 1904 introduced the polyuria test in association with ureteral catheterization. He established pretty firmly two principles: (1) that a function of a diseased kidney is more uniform than that of a healthy one and varies less from one examination to another the more extensively the parenchyma is destroyed; (2) when additional work is forced upon the kidneys when one is diseased and the other healthy or less diseased the response is more marked upon the healthy or less diseased side. Albarran has applied this as the basis of his polyuria

test. The technic is as follows: (1) The urine is first collected for one-half hour from each side and then 400 c.c. of water is administered. The urine is collected for each half-hour for three periods. The response is indicated by the more marked polyuria on the healthy or less diseased side. This is undoubtedly a valuable test, and particularly so because it tends to demonstrate some of the reserve force of the kidney. Unfortunately the test is not as practicable as would seem at first sight. In the first place it is not always possible to elicit a polyuria, even by the administration of large quantities of water, as has been our experience as well as that of Keyes, Jr.[8] (2) It is frequently difficult to get patients to drink these large quantities of water. (3) A polyuria may be present upon the diseased side prior to the test, and it may be well-nigh impossible to produce a response on the healthy side sufficient to overcome this polyuria on the diseased side. (4) In slight lesions of the kidney very little if any differences may be noted in the polyuria on the two sides. The test will be found much more practicable as a test of total function if revealing the variations possible in the concentrating power of the kidneys under study than when used in conjunction with renal catheterization.

Phenolsulphonephthalein.—This substance was first prepared by Ira Remsen. As described by his pupil Sohon this substance is a bright red, crystalline powder, somewhat soluble in water, more so in alcohol, insoluble in ether; it is readily soluble in solutions of sodium carbonate, and has a stronger avidity as an acid than phenolphthalein.

The pharmacology of this substance has been studied by Abel and Rowntree. It is entirely devoid of toxicity, and has the advantage over all other dyes so far advocated in that it is entirely excreted by the kidney with extraordinary rapidity. Whether given by mouth or administered subcutaneously, intramuscularly, or intravenously it is practically all excreted by the kidneys, and none of it is found in any other secretions of the body. When given in very large quantities traces of it can be detected in the stools. Following administration it is present in the bile, but is reabsorbed in the small intestine.

This substance has been introduced as a test of renal function by Rowntree and the writer.[6, 7, 10, 11]

The Specificity Displayed by the Kidney in the Excretion of Phthalein.—Six mg. of phthalein given intramuscularly to a patient weighing 60 kilos yields a dilution in the body of 1 in 10,000,000. An infinitely dilute solution is presented to the kidney, which within one hour under normal conditions, picks out 50 per cent. of these circulating molecules and passes them to the urine, sometimes as much as 3 mg. being excreted in 12 c.c. of urine, a dilution of 1 in 4000, or 2500 times the concentration in the blood. When the amount of blood only is considered in the question of dilution the concentrating power still remains several hundred, for when 6 mg. is given intravenously as much as 20 per cent. can be recovered in five minutes in 2 or 3 c.c. of urine.

At the same time in either instance the same concentration is presented to the liver, to the pancreas, salivary glands, sweat glands, and yet only a small amount appears in the bile while not a trace of it can be found in the pancreatic juices, saliva, or sweat. The capacity of picking out the molecules of sulphonephthalein from infinitely dilute solution and passing them on to the secretion in comparatively concentrated solutions is therefore a function specific to the kidney.

Mechanism of Excretion of Phthalein.—The work of Nussbaum indicating that the renal tubules in the frog's kidney are supplied by the renal portal system, which is entirely separate and independent of the arterial supply to the glomeruli, although discredited by Adami, was later shown by Nussbaum and Beddard to be absolutely correct. The work of Cullis also affords striking confirmation. By taking advantage of this independence of circulation of the tubules of a frog's kidney it is possible to furnish absolute proof that phthalein can be excreted by the cells of the tubules in the frog, and presumably this holds true for mammals. Bancroft and Straub have shown that after excluding the function of the renal tubules by profuse bleeding and the administration of large quantities of Ringer's solution an isotonic urine, a pure glomerular filtrate, can be obtained. The excretion of phthalein under such conditions was investigated. After profuse hemorrhage the excretion of phthalein decreased to approximately one-fourth what it was normally, while at the same time the concentration of the drug in the blood was doubled, so that with severe anemia the excreting power of the kidney was decreased to one-eighth of normal.

Unless the bleeding be very profuse, however, little effect on the phthalein excretion will be noted. The results obtained show that moderate degrees of anemia do not interfere with the excretion of phthalein, but that very severe grades of anemia, which Straub and Barcroft have shown to result in an entire removal of the tubular function of the kidney, materially decreases the output of phthalein, but at the same time shows that the glomeruli are also capable of extracting some of this drug.

Other Phenomena Bearing on the Method of Excretion of Phthalein.—The fact that the output of phthalein bears no relation to the excretion of chlorides also suggests that the glomeruli play only a minor role in its excretion. It is asserted by McKnider that in experimentally induced acute tubular nephritis produced by mercury bichloride and potassium chromate there is a marked diminution in the excretion of phthalein, while in the vascular type, produced by cantharides or arsenic, little or no decrease occurs at first, but a decrease does occur later. This suggests that the glomeruli play a subsidiary role in the phthalein excretion. The findings in work with diuretics, namely, that those substances which probably act by stimulating into activity the renal cells increase the phthalein output, while those diuretics which act mechanically, as by changes in blood-pressure or in osmotic tension,

do not influence the phthalein output, gives additional confirmation to the theory of activity on the part of the cells of the tubules in the excretion of phthalein.

The unrivalled advantages of this over all other excretory tests are these:

1. The complete elimination of the drug without chemical change by the kidneys.

2. The early appearance of the drug in the urine following its administration.

3. The rapid excretion of the drug by the kidneys, necessitating observation only over a short time.

4. The brilliancy of color which is imparted to alkaline urine and which is not readily influenced by the coloring matter of the urine itself.

5. The facility with which the drug lends itself to colorimetric methods, making accurate estimations possible.

6. The simplicity of the technic for quantitative estimation.

7. The non-toxicity of the drug.

8. The non-irritating nature of the drug locally.

9. The extreme smallness of the dose required and the assurance this gives of there being no extra strain placed upon the kidney during the test.

Technic.—In our earliest work only the time of appearance, the time of maximum intensity of excretion, and the time of gross elimination were considered. In the course of the work it became evident that the color properties of this substance make it peculiarly well adapted for colorimetric methods of estimation, and for this purpose the Doboscq colorimeter was employed and has proved of the greatest value.

In order to obtain data of real value it is essential to any functional test to know not only the time of appearance of the drug in the urine but exactly what part of the drug, a known amount of which has been administered, is recovered in a definite period of time.

Twenty minutes to half an hour before administering the test the patient is given 200 to 400 c.c. of water in order to ensure free urinary secretion, otherwise delayed time of appearance may be due to lack of secretion.

Under aseptic precautions a catheter is introduced into the bladder and the bladder completely emptied. Noting the time, 1 c.c. of a carefully prepared solution of phenolsulphonephthalein containing 6 mg. to the cubic centimeter is accurately administered subcutaneously, intramuscularly, or intravenously by means of an accurately graduated syringe.

The urine is allowed to drain into a test-tube in which has been placed a drop of 25 per cent. sodium hydroxide solution, and the time of appearance of the first faint pinkish tinge is noted.

In patients without urinary obstruction the catheter is withdrawn at the time of the appearance of the drug in the urine, and the patient

is instructed to void into a receptacle at the end of one hour and into a second receptacle at the end of the second hour.

A rough estimate of the time of appearance can be made by having the patient void urine at frequent intervals without the use of a catheter. In prostate cases it is advisable to have the catheter in place until the end of the observation. The catheter is corked at the time of the appearance of the drug in the urine and the cork is removed at the end of the first hour and at the end of the second hour, the bladder being thoroughly drained each time. On many of the patients of this type on whom our observations have been made a retention catheter has been in use as part of the routine treatment on account of the residual urine. When a catheter is to be employed it is well previously to have the patient under the influence of hexamethylenamin.

Each sample of urine is measured and the specific gravity taken. Sufficient sodium hydroxide (25 per cent.), is added to make the urine decidedly alkaline in order to elicit the maximum color. The color displayed in the acid urine is yellow or orange, and this immediately gives place to a brilliant purple-red color when the solution becomes alkaline. This solution is now placed in a 1-liter measuring flask and distilled water added to make accurately 1 liter. The solution is then thoroughly mixed and a small filtered portion taken to compare with the standard, which is used for all these estimations.

In our earlier work the amount of the drug excreted was estimated by means of the Duboscq colorimeter, the technic of which has been described in our original publication.

Recently the Autenrieth-Königsberger colorimeter has been modified by us and utilized for the quantitative estimation of phthalein. A standard alkaline solution, 6 mg. of phthalein to the liter, is placed in a wedge-shape cup. The urine, collected as for the other method, is diluted to a liter and a small filtered portion poured into the rectangular cup. The wedge-shape cup is now manipulated by means of the screw until the two sides of the color field are identical in intensity. The percentage is now read directly by the position of the indicator on the scale. This instrument is well adapted for the purpose, is approximately accurate, and is much cheaper than the Duboscq colorimeter.

Fairly accurate estimations, however, can be obtained by means of graduated cylinders, equal quantities of the standard solution and the diluted urine being used in separate cylinders, and the denser solutions being diluted until the colors became identical. The amount of drug in the solution being known, the amount in the urine can be readily calculated.

When the collected urine has been made strongly alkaline it is necessary to estimate the phthalein within a few hours, as the red color fades gradually under these conditions. When it is desirable or necessary to defer the estimation for some hours or days it is better to make the urine distinctly acid, under which condition the phthalein remains

unchanged. It should, of course, be made alkaline again when the estimation is made.

The method heretofore utilized in connection with other tests of determining the time necessary for total elimination is erroneous for the following reason: whereas in the case of phthalein a normal kidney excretes the greater part of the dye injected within two hours of the time of its administration, and then only a small trace for the next two hours, the moderately diseased kidney secretes a fair amount within the first two hours, say 50 per cent. of that excreted by the normal kidney, but the concentration in the blood still being high it continues to excrete a fair amount in the following two hours, so that at the end of four hours little difference may exist in the total work accomplished. One-hour and at most two-hour observations are therefore recommended. In cases in which only slight changes in function exist this can be most accuratedly demonstrated by one-hour collection following the use of an intramuscular (lumbar) injection.

The Influence of the Role of Absorption on the Rate of Excretion.—It must be admitted that a factor other than renal excretion, namely, absorption, enters in consideration in connection with the test when the phthalein is administered subcutaneously or intramuscularly. Obviously a considerable error is introduced from the stand-point of absorption in the use of the subcutaneous method, when factors, such as edema, which may modify the rate of absorption, exist. On this account the excretion in health following different methods of administration has been studied in some detail.

Intramuscular and Subcutaneous Absorption of Sulphonephthalein.—Meltzer and Auer were the first to demonstrate that absorption from the intramuscular tissue is much more rapid than that from the subcutaneous tissues. They worked with epinephrin, curare, fluorescin, and morphin, and demonstrated beyond doubt that these substances found their way into the general circulation much more rapidly when injections were made into the muscles. Patta was unable to detect any rise of blood-pressure following the intramuscular injection of epinephrin, and concluded that the results obtained by Meltzer and Auer were in reality due to intravenous injections. Wallace, working with epinephrin, obtained results identical with those of Meltzer and Auer, but also felt that the results were dependent on tearing of the veins, and were in reality intravenous injections. Joseph and Meltzer, in their work in relation to physostigmin in poisoning by magnesia salts, again demonstrated intramuscular absorption to be far superior to subcutaneous. Auer and Meltzer, by methods used with specific intention of detecting whether the rapidity of intramuscular absorption was dependent on the tearing of the veins during the injections or to the direct insertion of the needle into a muscle vein, proved satisfactorily that such accidents were not responsible for the rapidity of the absorption, but that rapid absorption occurs through the walls of the bloodvessels of the muscles. In the same communication they also

asserted that absorption from the lumbar is much superior to that from the gluteal muscles.

Phenolsulphonephthalein, by virtue of the properties whereby it is rapidly and quantitatively excreted by the kidney, furnished an excellent method of studying this problem. An investigation into the comparative quantitative excretion of phenolsulphonephthalein following these two methods of administration was consequently undertaken.

The first experiments were carried out on bitches. The time of appearance of the drug in the urine following subcutaneous administration of 1 c.c. of phthalein solution (6 mg.) and the quantitative output of phthalein for periods of varying lengths were determined. The lumbar muscles of these dogs were then exposed by a small incision, direct intramuscular injection made, and the time of appearance of the drug in the urine and the quantitative output for corresponding periods again determined. Finally, intravenous injections were given and similar observations were again made.

The time of appearance was determined as follows: A catheter was passed into the bladder and then 1 c.c. of sulphonephthalein was injected subcutaneously, intramuscularly, or intravenously. The bladder was then injected at 30-second and 1-minute intervals with small quantities of warm sterile boric acid solution, and this was immediately drained into flasks containing a few drops of sodium hydroxide. The first appearance of phthalein in the washings was noted and the amount of the drug excreted for the varying periods was then determined.

The results obtained from these observations appear in Table 1, from a study of which it will be seen that the time before appearance is shortest for the intravenous and that the drug appears much more readily (3.5 to 7 minutes) following an intramuscular than following a subcutaneous injection (5.5 to 12 minutes). The amount of excretion is dependent on the amount of absorption, the kidney function not playing a role inasmuch as the dogs were used throughout for these experiments, the kidney function being therefore approximately the same. It appears that the absorption for one hour from the subcutaneous tissues averages from 5 to 10 per cent. less than that from the intramuscular, while at the same time considerable variation (37 to 62.8 per cent.) exists in the absorption for the same dog (Dog 5, Table 1). The absorption from the intramuscular tissue for one hour appears to display less variation (58.8 to 67 per cent.), but the absorption is not absolutely complete, as the excretion for one hour is somewhat less than that following intravenous injection.

The difference, however, in the absorption from these two methods of administration is much more striking than one-half hour observations—over twice as much absorption following intramuscular injections as compared with subcutaneous (Dogs 4 and 5, Table 1). This suggested to us the necessity of comparing the curve of excretion in order to obtain the real difference in the rate of absorp-

TABLE 1.—COMPARISON OF EXCRETION OF PHTHALEIN IN DOGS FOLLOWING INTRAVENOUS, INTRAMUSCULAR (LUMBAR), AND SUBCUTANEOUS ADMINISTRATION.

	Time of appearance.			Amount first half-hour.			Amount one hour.		
	Subcutaneous.	Intramuscular.	Intravenous.	Subcutaneous.	Intramuscular.	Intravenous.	Subcutaneous.	Intramuscular.	Intravenous.
Dog 1	...	5.0	1.5	...	...	54.9	57.4	66.7	
	...	5.0	2.0	...	...	54.6	65.0	58.5	62.5
	...	7.0	...	...	...	...	50.0	55.6	
	8.0	...	...	...	...	...	50.0		
	10.0	...	...	...	...	...	50.5		
Dog 2	...	7.0	2.0	...	...	...	48.0	50.0	
	...	4.5	...	...	...	...	63.0	58.8	
	...	6.0	...	...	...	...	47.7	55.5	
	10.0	...	...	...	...	...	47.7		
	11.0	...	...	...	...	...	55.5		
	7.0	...	...	...	...	...	50.0		
Dog 3	...	3.5	2.0	...	...	50.9	37.6	52.6	64.0
	12.0	5.0	...	...	...	...	41.7	61.7	
	7.0	5.5	...	...	...	...	43.5		
	7.0	(x)	...	...	...	...	37.9		
Dog 4 pregnant	...	6.0	...	...	...	...	45.9		
	7.0	4.5	...	...	...	...	53.8	64.0	
	8.0	6.0	...	...	...	...	50.0		
	8.0	4.0	...	10.9	26.3	...			
	5.5	4.5	...	10.0	22.4				
	6.0	3.2	...	10.0	45.4				
Dog 5	...	5.0	2.0	...	...	58.3	50.0	64.9	71.3
	8.5	5.0	...	...	...	...	37.0	58.8	
	7.0	5.0	...	20.0	...	...	62.8	68.0	
	8.0	4.0	...	17.7	51.0	...	...	66.6	
	...	5.5	...	...	45.8				

(x) not read.

tion. Estimations were made at 10-minute intervals following injections by all three methods of administration. A comparison of the excretion in one dog (No. 5, Table 1) is indicated in Fig. 150. A similar comparison for the excretion in man following intravenous, lumbar, gluteal and subcutaneous administration is shown in Fig. 151.

Excretion in Normal Individuals and Variations Dependent on Methods of Administration.—The excretion has been studied in several hundred normal individuals. In our earlier work subcutaneous administration was used exclusively, the drug appearing in the urine in from five to eleven minutes, 40 to 60 per cent. (average 50 per cent.) being excreted in the first hour after its appearance in the urine, and 60 to 85 per cent. for two hours. In health the elimination is practically completed in two hours, only a trace being present during the third and fourth hours.

On account of the large variations in excretion in normal individuals following subcutaneous administration it was thought a large part of this variation might be due to tardiness of absorption. The excretion following intramuscular (gluteal or lumbar) injection was consequently investigated. After gluteal injection, variations from 14.7 to 62.5

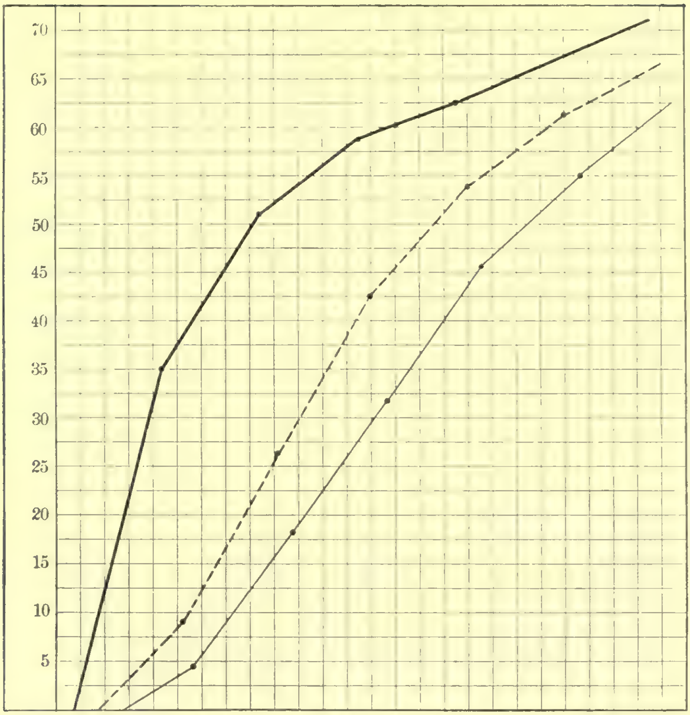

FIG. 150.—Curve of excretion in a dog for one hour, estimations being made at ten-minute intervals. Upper black line represents the excretion after intravenous, the dotted line after intramuscular (lumbar) and lower black line after the subcutaneous administration.

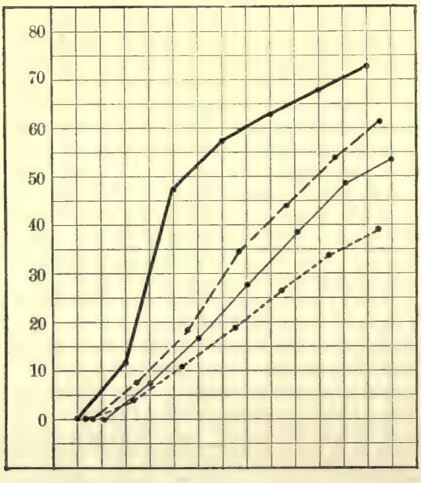

FIG. 151.—Curve of excretion in a man for one hour, estimations being made at ten-minute intervals. Upper black line represents excretion following intravenous injection; upper dotted line, excretion following lumbar injection; lower black line excretion following gluteal injection, and the lower dotted line represents excretion following subcutaneous injection.

per cent. were encountered for one-hour readings (ten minutes being allowed for time of appearance), an average of 51 per cent. being eliminated.

In twenty-one readings on fourteen normal individuals the variation following lumbar injection (Table 2) was 51.8 per cent. to 64.1 per cent., except in Case 10, in which the first test read 40.2 per cent., and there being some doubt as to the accuracy of the technic, three subsequent control injections were given showing an output of from 60 to 61 per cent. on each occasion. The average output of the twenty readings was 57.5 per cent. This would seem to indicate *that absorption plays a small role in affecting the accuracy of the test when one-hour determinations following intralumbar injections are employed.*

TABLE 2.—INTRAMUSCULAR INJECTION; LUMBAR.

Case.	Time of appearance, minutes	Percentage excreted. First half-hour.	Second half-hour.	One hour.
1. G.	8	37.7	16.1	53.8
2. D.	6	19.2	35.7	54.9
3. O.	6	45.8	16.6	62.4
4. S.	7	32.5	21.8	54.3
5. G.	7	32.3	26.3	58.6
6. M.	..	32.3	21.7	54.0
	..	33.3	21.0	54.3
7. Y.	7	26.3	26.3	52.6
8. N.	6	33.3	29.8	63.1
9. J.	8	29.0	25.0	54.0
10. M.	7	23.0	17.2	40.2
	8	..	..	60.9
	..	..	..	60.2
	..	..	..	60.2
11. S.	6	..	..	60.7
	..	..	..	64.1
	7	38.8	24.4	63.2
12. G.	8	..	..	51.8
13. R.	5	..	..	62.5
	..	..	..	62.5
14. G.	8	34.0	26.2	60.2
Average				57.4

Intravenous injections have been employed (Table 3) with three ideas in view, namely, in order to determine: (1) the total excretion for one hour; (2) what variations in kidney function existed in normal individuals; (3) to what extent absorption was responsible for variations in excretion. The output for one hour (twenty readings in fourteen individuals) averaged 67.9 per cent., considerably higher than that from other methods of administration. The excretion varied from 62.5 to 80 per cent., with one exception, No. 9, who excreted 57.8 per cent. This individual gave a somewhat low output following all methods of administration, although no other evidence of renal disease could be discovered.

Table 4 shows the variations in percentage excretion for one-hour periods in the same individuals following subcutaneous, gluteal, lumbar and intravenous administration.

TABLE 3.—INTRAVENOUS INJECTION IN NORMAL CASES.

Case.	Time of appearance, minutes.	Percentage excreted. First half-hour.	Second half-hour.	One hour.
1. U.	5	56.8	23.3	80.1
2. L. C.	4	53.2	10.8	64.0
3. S. B.	4	66.6	13.4	80.0
4. K.	?	..	..	70.0
5. S.	3.5	..	..	62.5
	4	..	..	62.5
	4	..	..	63.3
6. D.	4	..	..	70.0
7. L.	..	58.8	13.2	72.0
8. C.	..	64.1	13.8	77.9
9. S.	(x)	46.7	11.1	57.8
10. J.	..	55.5	9.0	64.5
	..	62.5	10.2	72.7
11. P.	6.5	..	..	66.6
12. M.	4	..	..	62.5
	..	..	..	65.8
	..	..	..	65.5
13. S.	4	..	..	62.5
14. Y.	4	..	..	71.5
	..	..	..	66.5
Average				67.9

(x) Question as to being normal.

TABLE 4.—EXCRETION IN NORMAL INDIVIDUALS FOLLOWING FOUR DIFFERENT METHODS OF ADMINISTRATION.

Case.	Intramuscular (lumbar).					Intravenous.		
	Subcut., one hour, per cent.	Gluteal, one hour, per cent.	First half-hour, per cent.	Second half-hour, per cent.	Total for hour, per cent.	First half-hour, per cent.	Second half-hour, per cent.	Total for hour, per cent.
1. C.	53.2	62.5	..	..	..	64.1	13.8	77.9
2. L.	..	58.9	..	..	..	58.8	13.2	72.0
3. S.	35.7	46.6	..	..	..	46.7	11.1	57.8
4. S.	52.6	53.7	..	..	..	..	..	62.5
	..	..	..	..	..	..	..	62.5
	..	..	..	..	..	..	..	63.0
5. S. B.	38.8	..	..	..	..	66.6	13.4	80.0
6. U.	41.6	49.0	..	..	..	56.8	23.3	80.1
7. M.	..	..	..	..	..	..	..	62.5
	43.1	43.4	32.3	21.7	54.0	..	..	65.8
	58.8	..	33.3	21.0	54.3	..	..	65.5
8. S.	42.7	47.6	..	..	..	..	..	62.5
9. Y.	60.9	41.7	26.3	26.3	52.6	..	..	71.5
	44.3	..	..	..	..	..	..	68.5
	45.5							
10. B.	42.0	57.7						

Excretion in Nephritis.—Functional tests in the past have not been considered of any great value to the clinician in relation to nephritis. A study of the phthalein output in different forms of nephritis was made by Rowntree and myself with the following results:

Acute Nephritis.—Although the number of acute cases studied was small, in none of them was there increased permeability, but, on the

contrary, the permeability was markedly decreased when the condition was considered clinically grave. It should be remembered, however, that when an acute process is present, variations in function may be very rapid and that a good elimination on one day may be followed within a day or two by a marked decrease in function, and *vice versa.* Consequently, in cases of this type the test should be repeated frequently.

Chronic Parenchymatous Nephritis.—A series of 25 cases belonging to this type of nephritis was studied. The cases represented different grades of severity and duration of the disease from a few weeks to seven years. In 5 very mild cases of short duration showing only slight edema, with albumin and casts, but with a normal urinary output, the time of appearance of the drug and the amount excreted was normal. In cases of longer standing or cases in which the disease was of ordinary severity the time of appearance was always found delayed and the amount excreted definitely below normal. In the most severe course of chronic parenchymatous nephritis, or where the disease was of long standing and associated with secondary sclerotic changes, the output was reduced very markedly and in some instances no trace of the drug could be found in the urine. Here, also, as in the interstitial type, the absolute failure of excretion or the excretion of a mere trace, was followed in a short time by death from renal failure. Sufficient data was collected to indicate that the test is of decided value in revealing the functional efficiency of the kidney in this condition. In the mild cases very little disturbance of function was indicated, and it may be impossible for the test alone to differentiate this condition from albuminuria unassociated with gross renal lesions. When there is a marked decrease in the phthalein output, marked renal changes are present, and when only excreted in traces or not at all a grave prognosis should be given, even although no signs of uremia exist.

Chronic Interstitial Nephritis.—In many of the cases studied previous to the administration of the phthalein test no accurate idea of the degree of involvement of the renal function could be ascertained even after the most careful clinical study. The phthalein test proved itself of immense value in revealing the degree of destruction of the renal substance and demonstrated this to be of extreme importance from the stand-point of both diagnosis and prognosis. In most of the cases the time of appearance was found markedly delayed and the output of phthalein markedly decreased. When the output was lowest the delay in appearance was most pronounced. The time of appearance, however, is not so important as the amount of excretion. Chronic nephritis can exist over a long period without recognition and may even exist in the absence of albumin and casts in the urine. In the absence of positive clinical proof the phthalein test frequently proved of value in revealing the presence of chronic nephritis, and also aided in differentiating clinically various forms of toxemias from true nephritis with uremia.

Uremia.—Twenty-five cases were studied in which uremia was present. In 16 of these the uremia was grave, the patients exhibiting nausea and vomiting, drowsiness and coma, and in several instances convulsions. In the remaining 9 cases mild symptoms only were present, which had persisted over long periods. Eleven of the 16 patients with grave uremia died during the attack. In all of these cases the phthalein elimination was zero or a faint trace only after two hours. Of the 5 patients recovering from their uremia, in two instances the output was 20 per cent., the uremia being the result of an acute exacerbation of a chronic nephritis. In 2 the output was 14 per cent. in both of which the uremia was precipitated by a double pyelonephritis. The fifth case was an acute exacerbation in a case of chronic pyelonephritis in a man previously having had nephrectomy. In mild cases exhibiting persisting symptoms of uremia, the excretion respectively was as follows: 10 per cent. in 1, 7 per cent. in 3, a trace in 1, 2 per cent. in 1 for two hours. Four of the patients died within three months of the performance of the test. In 2 patients not exhibiting uremia, but with a markedly decreased phthalein output, operation with long ether anesthesia in each instance was followed by uremia and death.

Cardiac and Cardiorenal Cases.—An attempt was made to differentiate by means of the test between those cardiac cases with broken compensation and passive congestion of the kidney associated with albumin and casts in the urine and those cases in which cardiac insufficiency is associated with varying grades of true nephritis. From a study of these cases there appears to be no doubt but that decrease in function accompanies chronic passive congestion of the kidneys in the absence of any true nephritis. As the cardiac condition improves, however, the passive congestion becoming less marked and the edema subsiding, the output of phthalein increases. In those cases with broken compensation which presented a high phthalein excretion in nearly every instance, albumin and casts entirely disappeared with the improvement of the cardiac condition. The presence of a general anasarca, particularly when edema existed at the point of injection, probably introduced some error from a stand-point of absorption. From a study of these cases we feel that the phthalein test will prove of value in determining what degree of renal insufficiency exists in this class of disease. With improvement in the cardiac condition and the disappearance subsequently of edema a continued low phthalein excretion will indicate with considerable certainty the presence of permanent organic changes in the kidney.

The Relation of Phthalein Output to Blood-pressure, to Changes in the Eye-grounds, and to the Blood Picture.—In the majority of cases of chronic nephritis in which the blood-pressure has been high the phthalein elimination has been markedly decreased, but no exact parallelism exists, inasmuch as not a few instances have been encountered in which the systolic pressure has been over 200 mm. (Hg.) and

the phthalein output one-half of normal, while, on the other hand, there have been instances in which the blood-pressure has been normal while the phthalein output has been zero or nearly so, the patient shortly afterward dying in uremia. While the high blood-pressure when present is considered of diagnostic and prognostic value in conjunction with other clinical data, yet many patients died of renal insufficiency and exhibited a blood-pressure which was normal or practically so; nor is the blood-pressure even when high increased in inverse proportion to the decrease in renal function. While in some instances marked changes in the eye-grounds, choked disks, tortuous vessels, hemorrhages, etc., have been present, coincident with a very low phthalein output, in many cases, even of the most advanced and even fatal nephritis, no changes whatever in the eye-grounds could be detected, the patient at the same time failing to eliminate the phthalein. Moderate or rather severe grades of secondary anemia in the absence of disease of the kidneys can be present without any diminution in the phthalein elimination. When, however, the anemia is so severe that the oxidation processes of the kidney are interfered with there may be a marked decrease in the phthalein excretion.

Value of the Test from a Surgical Stand-point.—A study of the phthalein excretion was undertaken in a large series of cases of urinary obstruction in order to determine the value of the test in revealing the functional capacity of the kidney in this condition. This is a consideration of grave importance, since the development of uremia or renal failure has been responsible for a considerable part of the mortality following surgical interference.

As a result of obstruction in the lower urinary tract, pathological changes may occur in the ureters and kidneys, dilatation of the ureters, varying grades of hydronephrosis, and, as a result of the continued high pressure, atrophy of the parenchyma of the kidney. Not infrequently infection occurs with the development of a pyelitis, a diffuse or localized pyelonephritis, or a pyonephrosis. The occurrence of these complications is often difficult of recognition, and is often overlooked, particularly in the absence of symptoms of renal inadequacy. A large proportion of these cases of urinary obstruction have cystitis associated with albuminuria. The presence of casts in the urine is no contraindication to operation. The urinary output may be normal in many instances, also the urea and total solids, and yet the patient may be on the verge of renal failure, and disastrous results may follow surgical interference.

The technic involved in these cases necessitates the use of a catheter, otherwise it does not differ from that described above.

In the majority of cases the test indicates more or less of renal impairment, and, taken in conjunction with the clinical condition, it is of more value than the study of urine output, total solids, total nitrogen, and urea estimation combined.

A marked decrease in the amount excreted invariably means severe

derangement of renal function, which may be of either a temporary or permanent character. Under such conditions one should proceed with extreme caution, and no surgical intervention should be attempted without further study, together with preliminary treatment. This preliminary treatment consists of drainage by means of a retention catheter or frequent catheterization, together with the administration of large quantities of water.

Under this regimen repeated functional tests will demonstrate eventually the nature of the derangement, for in true interstitial nephritis the output will continue low, whereas if the derangement is purely functional or secondary to pyelonephritis, usually improvement will follow as a result of the treatment, and will be indicated by a decrease in the time of appearance of the drug and simultaneously an increase in the amount eliminated.

The functional derangement due to infection in these cases is a much more dangerous condition that is the presence of even a fairly advanced condition of interstitial nephritis. The use of the test enables one to select a favorable time for operation. When only a trace of the drug continues to be excreted, operation should not be attempted at all except in an emergency, even though the patient presents no evidence of uremia.

We have considered a dropping phthalein output as a contra-indication to operation except in cases of necessity. This decrease in function usually means some change in the renal condition, and in most of our cases it has been caused by the development of a pyelonephritis or an exacerbation of an old process. It is obviously wise to wait until the kidneys have recovered from this acute shock before subjecting them to further injury through operation.

As regards the amount of excretion below which one should not operate, we do not attempt to draw a definite line. The test simply indicates the renal function, and it depends on the operator what risks he is willing to assume, the probabilities of fatality increasing as the phthalein output decreases. We do, however, recognize when we have a low function which otherwise may be unrecognized, and have found that preliminary treatment, whether it be by suprapubic, perineal, or catheter drainage, allows a regeneration of function which is indicated by the test, and the patient later undergoes the graver operation of prostatectomy with less risk.

The test can be used to equal advantage preliminary to any surgical procedure when it is deemed important to know the true functional capacity of the kidneys.

Results Obtained with the Phthalein Test in Unilateral and Bilateral Disease of the Kidney.—In normal cases the time of the appearance of the drug from the two sides has been almost always the same, and in the majority of cases this has been five to ten minutes following subcutaneous and three to five minutes following intravenous injection. The time of appearance, of course, will vary somewhat with the rate of

urinary secretion. Normally the amount excreted by each kidney will be practically the same.

When one kidney is diseased the time of the appearance of the drug is delayed on the diseased side and the amount excreted is not only relatively but absolutely decreased. The amount of delay in the time of appearance is comparatively of little value. Reliance is to be placed only on the quantity excreted during the period of one-quarter, one-half, or one hour, dependent on the method of administration.

Although in the majority of these cases of unilateral disease the combined output is equal to that of two normal kidneys, the greater part of the excretion is shown to be performed by the healthy kidney. In proportion to the decrease in function on the diseased side, approximately there is a proportionate increase in the function on the healthy side. In such cases following nephrectomy the remaining kidney eliminates, after the lapse of two or three weeks, an amount of drug which is normally excreted by two healthy kidneys. In all cases studied the output from the remaining kidney has been greater than the combined output from the two kidneys prior to operation.

While the total urea from the combined urine is no true index of the functional activity of the kidneys, the comparative urea output from each kidney is of decided value. The same amount of urea is presented to each kidney for elimination, and therefore it is possible to estimate to some extent the proportionate amount of work which each kidney is performing. Barring has pointed out that when the output from one kidney is four times as great as that from the other it is safe to remove the diseased kidney, provided that the urine from the opposite side gives no indication of disease. It is of most value when there is a marked disproportion between the two sides. This test, however, has its failings, as this proportion does not always exist. Again, the urea determination indicates only the relative amount of work that each kidney is performing, and as the exact amount of urea present in the blood is not known, the test shows only the relative activity of each kidney and not their absolute functional activity.

Again, it affords no indication as to whether the kidney is working at its ordinary capacity or as to whether the reserve force is called on and the kidney is working at its maximum, and therefore unable to withstand any additional strain.

The inefficiency of these methods has necessitated the introduction of the more recent methods of estimating the functional ability.

A striking parallelism exists between the relative amounts of phthalein excreted and the relative urea output for any period, but the phthalein has an additional advantage, inasmuch as it indicates not only the relative excreting capacity of the two kidneys, but furnishes an approximate idea of the absolute capacity of each kidney.

In bilateral disease it has been found possible to determine the individual function (absolute or relative) of each kidney. It is in this class of cases particularly that the shortcomings of the other func-

tional tests have been most apparent, as one kidney may be doing twice or three times the amount of work of the opposite kidney and still be unable to assume the additional work of the other kidney. It may be doing the major part of the work at the expense of all or nearly all of its reserve power, but the phthalein test determines whether the kidney has a functional capacity which is normal, less than or greater than normal, and to what degree. In 2 cases of double renal tuberculosis in which the amount of pus from each side was practically the same the test permitted it to be determined that in each instance one kidney had a function greatly in excess of the other—indeed, sufficient functional capacity to allow of successful nephrectomy, marked improvement in general condition occurring subsequently in each case.

The existence of an infantile kidney may be readily overlooked, inasmuch as under normal conditions the urine from such a kidney may be absolutely normal so far as color, specific gravity, and urea percentage is concerned. The literature abounds with numerous reports of death from renal failure following nephrectomy due to the inability to recognize the presence of an infantile kidney. Recently, Kümmel and McArthur have each reported deaths following nephrectomy when an infantile kidney had been left to assume the work. In our series two such kidneys, the seat of disease, have been removed, and in a third case with bladder tuberculosis and suspected renal tuberculosis, without localizing symptoms on either side, an exploration of the left kidney revealed a healthy but infantile kidney. Exploration was necessary, inasmuch as the bladder was markedly contracted, and it was found impossible to catheterize the ureters. A similar condition was encountered in a cat utilized in our experimental work.

When the disease is present in a large kidney nothing short of functional tests will reveal the presence of the infantile kidney.

In certain cases, owing to malformation or strictures in the lower end of the ureters, and especially in tuberculosis of the bladder, it may be possible to catheterize one ureter only. When infection of the bladder exists, microscopic and chemical examination of the urine collected transvesically is obviously unreliable as an indication of a healthy or diseased condition of the uncatheterized side. It is therefore necessary to resort to estimation of functional capacity in order to determine the presence or absence of disease on the side not catheterized.

In many instances of tuberculosis it is the healthy kidney which can be catheterized and the absolute evidence of disease on the other side in the presence of an infected bladder must be ascertained, not by microscopic examination of the urine, but by functional capacity.

Occasionally it is impossible to catheterize either ureter, particularly in marked vesical tuberculosis. Here by the aid of indigo-carmine, noting the time of the appearance of the drug on each side and from the evidence obtained from cystoscopy and from localizing clinical symptoms, it will generally be possible to arrive at a probable diag-

nosis as to which kidney is involved. The total function as determined by means of phthalein will determine whether the disease is unilateral or bilateral. When one kidney is suspected, and yet a good total renal function has been indicated, this side can be explored, and if found to present evidence of marked disease can be removed with safety without exploration on the opposite side. Obviously, excretion of a large amount of phthalein must have been performed by the opposite kidney.

The test has been used by us simultaneously with cryoscopy, phloridzin, indigo-carmine, and the polyuria test of Albarran. No particular advantage was added by combining with one or all. Indigo-carmine and phenolsulphonephthalein may be combined as follows: Following the appearance of phthalein after injection, 5 c.c. of 4 per cent. indigo-carmine suspension is injected into the gluteal muscles and the time of appearance in the acid urine noted. While the amount of phthalein excreted can be estimated with a fair degree of accuracy in the presence of indigo-carmine by rendering the urine alkaline and boiling, on the other hand the amount of indigo-carmine excreted can be estimated after acidifying with hydrochloric acid or sulphuric acid at the best only roughly, and occasionally not at all. When the two substances are used simultaneously the whole test is complicated with the introduction of no advantages and some added difficulties.

Inhibition of Function as the Result of Ureteral Catheterization.—As pointed out by Kapsammer a change in function of the kidney sometimes results from the introduction of the ureteral catheters, and may occasionally seriously interfere with the value of quantitative determinations of the renal function. Following catheterization, anuria is most frequent, but sometimes polyuria occurs, and even in the presence of polyuria inhibition of secreting function, urea, etc., may be present. In our series a moderate grade of inhibition has been noted in 6 cases out of 70. This inhibitory influence of the catheters can be readily detected by determining the total function without the use of catheters, which should always be done as a control. In no instance in our series was the inhibition of such a grade as to interfere seriously with the value of the test. This inhibition of function from the ureter catheters has also been noted by Keyes, Jr., and A. R. Stevens. The most serious disturbance in our experience occurs shortly after the introduction of the catheters, and it is wise to wait until urine is dropping freely before giving the phthalein injection. If this technic is followed, inhibition will probably not play an important role in the great majority of cases.

Renal Function before and after Nephrectomy.—This problem has been investigated from the experimental and from the clinical side. During the course of active secretion, cats being employed, one kidney was suddenly tied off, the quantitative secretion of urine and phthalein being subsequently studied and compared with the excretion prior to this nephrectomy; the conditions of the experiment, of course, being

kept absolutely the same after the removal of the one kidney. In the majority of instances a slight fall in both quantity of urine and in the phthalein excretion occurred immediately after tying off the one kidney; occasionally the phthalein remained the same for one-quarter or one-half hour and then gradually fell, and in one instance the urinary flow was increased while the phthalein output remained practically the same.

One case is of particular interest, inasmuch as the removal of one kidney greatly reduced the urinary flow and at the same time reduced the phthalein output to one-fiftieth of its former level. This finding was unique. In this case, however, it was found that the remaining kidney was congenitally atrophic or infantile in character and weighed only 6.4 grams, while the kidney which had been removed weighed 26.4 grams. This is a striking example of the value of the test in detecting the true functional capacity of a kidney.

Tests of Retention.—Practically all of the waste products of metabolism are eliminated by the kidneys, and the greater part of this is in the form of urea. Urea and the allied nitrogenous substances are not formed in the kidneys but are brought to them in the blood for elimination. The nitrogenous substances of the urine other than urea and uric acid are little affected by the diet. Urea varies almost directly with the food protein, which is probably converted during digestion into ammonia and amino-acids and is then changed by the liver into urea, which is carried by the blood to the kidneys and excreted without entering into tissue formation at all (Folin). Uric acid is variable with the amount of such food as livers, sweetbread, bran, etc., and uric acid and urea do not run parallel in either the urine or blood. Prevost and Dumas, in 1823, observed an accumulation of urea in the blood of nephrectomized dogs. Bostock, in 1829, noticed an increase in the blood urea of certain cases of albuminuria, and Brigh and his co-workers, in 1836, confirmed this observation and recognized it to be of clinical importance in nephritis. Schondorf, in 1899, Ascoli, in 1901, and Strauss, in 1902, made extensive studies and found that in cases of severe nephritis there was usually nitrogenous accumulation. Miller found urea retention to be of great value in diagnosing cases of uremia. Widal, in 1911, using the hypobromite method, based the prognosis on the amount of the urea in the blood, stating that patients with one or more grams per liter rarely lived more than a year, with 2 or 3 grams only months or weeks, and with more than 3 grams a very short time. When the high blood urea was secondary to renal obstruction and such obstruction could be removed the prognosis was more favorable. He believed the amount of blood urea was of definite value in the prognosis, especially of those cases difficult to determine from the clinical symptoms alone. Foster found a considerable increase in non-protein nitrogen in severe nephritis and in some other conditions. Rowntree and Fitz, in an extensive study, found that the accumulation of non-protein nitrogen in the blood of nephritics was of prognostic value. In experi-

mentally produced nephritis (uranium, cantharidin, chromate, arsenic, etc.) in animals, non-protein nitrogen retention has been found to occur. Folin and Dennis and Semar, in 1914, reported clinical experiments showing the relation of the non-protein nitrogen and the urea of the blood of nephritics to the amount of protein intake, and were able to show that the urea content of the blood in nephritics varied to a not inconsiderable degree with the protein intake. They found no parallelism between nitrogen retention and blood-pressure. Studies of nitrogen retention have until recently been handicapped by the want of a simple clinical method of estimation. The earlier methods were too complicated, while the sodium hypobromite method introduced in 1872 by Yuon has been repeatedly shown to be most inaccurate. Folin and Dennis, in 1912, introduced accurate and simple methods for non-protein nitrogen determination, and Marshall, in 1913, has simplified still more a method for accurate urea determinations in both the urine and blood. For all practical purposes most of the information regarding nitrogen retention in the blood can be obtained by estimation of the urea content, as urea forms 60 to 76 per cent. of the total nitrogen and variations in the total non-protein nitrogen practically parallel to variations in the urea nitrogen blood urea. Today estimations of the blood urea is the best of retention most frequently employed, and in the majority of cases supplies all the information which can be obtained from any of the tests of retention. Marshall's[9] method for estimating the urea both in the urine and in the blood is the simplest and the most accurate. The principle of Marshall's method consists in the conversion of the urea into ammonium carbonate by means of an enzyme urease present in an extract of the soy bean and a titration of the standard hydrochloric acid and methyl orange. The technic for the estimation of the urea in the urine is as follows: "Two 5 c.c. portions of urine are measured into flasks of 200 to 300 c.c. capacity and dilated with distilled water to about 125 c.c. Two c.c. of the enzyme solution are added to one flask, a few drops of toluol to each, and the solutions allowed to remain well stoppered at room temperature overnight or placed in the thermostat at 38° for one hour. The fluid in each flask is titrated with A_{10}NACl and methyl orange. The amount of hydrochloric acid required for neutralization of the contents of the flask containing the urine and enzyme solution less the amount required for neutralization of the 5 c.c. urine alone and 2 c.c. enzyme solution alone corresponds to the urea originally present in the urine. This value multiplied by 0.6 gives the number of grams of urea per liter of urine."

For the determination of the blood urea the technic is as follows: "Two equal portions of the serum 3 c.c. or 5 c.c. are measured into two small test-tubes; 1 c.c. of the enzyme solution added to one, toluol to each, and the tubes allowed to remain overnight or placed in the thermostat for one hour. The contents of each tube are washed into tall cylinders, and alcohol and sodium carbonate added to the ammonia

removed by means of a strong air current. The ammonia is collected in flasks containing 25 c.c. N/50 hydrochloric acid. When all the ammonia has been driven over the excessive acid in the flasks it is titrated with N/50 solution hydroxide and sodium alizarin sulphonate. The amount of hydrochloric acid required to neutralize the ammonia from the serum and enzyme solution less the amount required for the ammonia and the serum alone represents the urea present in the amount of serum taken."

The work of Folin and Dennis[4] indicates that a concentration of urea 0.5 grams and the total incoagulable nitrogen 0.6 grams per liter heretofore considered normal must no longer be so considered since in 16 strictly normal persons the highest non-protein nitrogen was 26 mg. and urea nitrogen 13 mg. per 100 grams blood. Slight nitrogen retention may apparently occur in many diseases, but in our experience in a large number of cases, using the later methods and also Marshall's new urease method, we feel that no great prognostic significance is to be attached to concentrations less than 0.55 gram per liter. Greater concentrations than this are of considerable prognostic importance. It has been shown by Schwartz and McGill[12] and by others that a definite increase in the blood urea may be encountered in many diseases other than renal.

Folin and Dennis considered a high retention a safe indication of impending uremia, but Foster has called attention to the fact that uremia may be present with a nitrogen retention which is practically normal or moderately increased, so that he does not consider nitrogen retention as necessarily associated with uremia but merely possibly coincident. Farr and Austin[3] found practically no retention in chronic nephritis with edema and albuminuria, but other cases with hypertention always showed a figure between 0.4 and 1.8 grams of non-protein nitrogen. Cardiovascular cases with renal congestion but without renal disease gave no evidence of retention. Uremic states were invariably associated with retention, but no relationship could be established between the decrease or increase in the tendency to uremia. Marshall and Davis have shown conclusively that there exists in all organs of the body the same urea concentration that is present in the blood, so that when we estimate the urea concentration in the blood we are estimating the urea concentration in the body tissues as a whole. Estimation of the amount of urea excreted in the urine is of itself practically valueless unless taken in consideration with the protein intake or with the amount of urea in the blood. In occasional cases in which the urea excretion is found very low over a considerable period of time it usually indicates severe renal disease. The greatest value of urea estimations in the urine is in association with ureteral catheterization. As the same quantity of urea is presented to each kidney an estimation of the quantity of urea excreted by each kidney during a definite interval of time is a true index of the relative functional power of the two kidneys. It has been shown by

numerous workers that there is more or less a relation between the amount of water and the amount of urea excreted; the more water the more urea. Foster has called attention to the fact that it is possible in certain cases of nephritis with high non-protein nitrogen retention to considerably reduce this by increasing the water output. According to Weill the maximum concentration of urea possible in the urine is about 53 grams per liter.

UREOSECRETORY OR AMBARD'S CONSTANT.

Ambard has ascertained that certain laws govern the interrelationship of the amount of urea in the blood and urine when the kidneys are normal. Hinman has summarized the work of Ambard.[1]

1. When the kidney excretes a urine of a constant concentration its urea output varies as the square of the concentration of urea in the blood. The concentration of urine urea is expressed in grams per liter (C). The urea output represents the number of grams of urea excreted in the observed time corrected for the theoretical volume in 24 hours (V). The corrected volume (V) times the urea concentration (C) gives the urea output (D). The concentration of the urea of the blood (Ur) is also expressed in grams per liter. Therefore, provided the urine has a constant concentration, the blood urea divided by the square root of the urea output is a constant.

$$K = \frac{Ur}{\sqrt{D}}$$

2. When a urine of variable concentration is excreted and the urea concentration of the blood is constant the urea output will be inversely proportional to the square root of the concentration of the urea in the urine. To test this law an arbitrary urea output is calculated for an arbitrary concentration of 25 grams per liter (D_{25}) from this equation:

$$\frac{D_{25}}{D} = \frac{\sqrt{C}}{\sqrt{25}} \text{ or } D_{25} = \frac{X \times \sqrt{C}}{5}$$

which leads up to the third law:

3. When the concentration of the urea in the blood and in the urine are both variable the urea output varies in direct proportion to the square of the concentration of the urea in the blood and in inverse proportion to the square root of the concentration of the urea in the urine. Thus:

$$K = \frac{Ur}{\frac{D \times \sqrt{C}}{5}} \text{ or } K = \frac{Ur}{D_{25}}$$

The original formula of Ambard corrected the patient's body weight for an arbitrary weight of 70 kg. on the supposition that a large

man would have correspondingly large kidneys. Legueu and recent workers with the "constant" consider this correction unnecessary.

Great accuracy is necessary in the urine collections, the time measurements, and the urea determinations. The loss of a few c.c., an error of a few minutes in the collection, or a difference of only 1 mg. in the urea estimation vitiates the result markedly. For these reasons the method is valueless (Legueu) in comparative studies with ureteral catheters (leakage, inhibition, stimulation). For the estimation of total function, however, a host of French workers hold the method in great esteem as furnishing the "balance of precision" in connection with blood urea. Recently Widal, Weill and Radot (July, 1914) after a comparative study of blood urea, Ambard's constant, and the phthalein test found all three tests ran remarkably parallel, rising and falling together both in normal and nephritic patients. They confirm the precision of each test, but because of this parallelism, favor the choice of the simplest technic, which is that of phthalein, and they remark in addition that phthalein is free from many errors to which others are liable.

The normal constant varies between 0.06 and 0.08. Weill has found that ordinary polyuria, oliguria, changes in diet, variations in chlorides, and different positions do not affect the constant. Fever, diabetes, anemia, and hydroligneous nephritis may lower the constant. A high constant, the technic being accurate, invariably means renal insufficiency.

Example of estimation of constant of Ambard in case two days after nephrectomy for tuberculosis. Urea determinations by Marshall method. Duration of urine collection, one hour. The second hour collection for a phthalein test was used, = 52 c.c. $V = 52 \times 24 =$ 1248 c.c. Urea per cent. = 23 per liter. Urea output = 1248×23 per cent. = 28.70 (D). Corrected for concentration of

$$25 \text{ per cent.} = 28.70 \times \frac{\sqrt{23}}{5} = 28.70 \times 0.84 = 24.10.$$

Blood taken 20 minutes after onset = 0.498 gram urea per liter.

$$K = \frac{Ur}{\sqrt{D_{25}}} = \frac{0.498}{\sqrt{24.10}} \qquad \frac{0.498}{4.9} = 0.1$$

Phthalein test (taken at same time) appeared: ten minutes, first hour 32 per cent.; second hour, 12 per cent.

CRYOSCOPY.

In estimating the work performed by the kidney, cryoscopy has occupied an important position. The work of Raoult and Van Hoff, showing that the osmotic pressure is proportional to the molecular concentration of the solution, and that this is definitely and constantly related to certain other properties, such as lowering of freezing-

point, has been applied by Dresser and Koranyi in determining the work performed by the kidney. The freezing-point △ of normal urine was easily ascertained, and found by Koranyi to be only fairly constant, varying between −1.30 and −2.20. Later work, however, seems to indicate that these limits are still too narrow, and that slight causes (neurosis with movable kidney, and polyuria) may greatly reduce the △. Hamburger has also pointed out that urates are frequently precipitated at the freezing-point, which, of course, gives rise to serious error.

Other methods are in use for the consideration of the △ in relation to the chloride content of the urine, or in relation to the chloride content under forced chloride intake, etc.

Cryoscopy is probably the most accurate way of obtaining the molecular concentration of total solids excreted; but so many factors influence this, for instance diet, water intake, etc., that no real assistance is gained from this method of study of the urine alone.

Koranyi has shown that the molecular concentration of the blood is about constant in health, −0.56. Leon Bernard has introduced comparative cryoscopy of the blood and urine, and this has proven of most value in indicating the functional efficiency of the kidney. It has been demonstrated that in severe bilateral kidney disease usually the molecular concentration of the blood is raised and the freezing-point lowered, while simultaneously the molecular concentration of the urine is lowered and the freezing-point is raised.

In our experience[5] in a series of 34 cases in which cryoscopy was employed, variations from 0.48 to −0.71 were encountered. All of the patients tested were suffering from obstruction in the lower urinary tract. In every instance except one a normal phthalein was found associated with normal freezing-point, while a decrease in phthalein output of serious import may be associated with a normal △. Cryoscopy is very little employed because more accurate methods have been substituted.

ELECTRICAL CONDUCTIVITY OF THE URINE.

The electrical conductivity of the urine in health and in disease was first studied by Dawson Turner. His method determines the amount of salts in the urine. The electrical conductivity is estimated in ohms of resistance and is entirely dependent upon the number of ions in the solution, and consequently takes into account principally the inorganic chemical constituents of the urine.

The well-known Kohlrausch method, consisting of a Wheatstone bridge, resistance box, telephone and the ordinary conductivity cells is employed.

Comparative studies of the urine and the blood or serum have been made also by Turner. "A blood of high resistance indicates that the proportion of salts in the blood is small and that the proportion of

corpuscles present is large. Hence a high resistance of the blood but a low resistance of the urine is indicative of health." A hemorenal salt index—the ration of the electrical resistance of the blood and urine—has been suggested. The normal index is 3. Any index above 3 indicates greater health, while an index below 3 means disease. Surgical interference with the kidney is considered dangerous with an index lower than 3.

This test has been very little used. The apparatus is expensive and skill and training are necessary before accurate readings can be made. The study of the urine itself is not sufficient, as it may vary widely in health, depending on water or salt intake. It is necessary, therefore, to consider the blood or serum as well as the urine.

These physical methods are undoubtedly exceedingly accurate for determining the total solids or total ions, but without accurate knowledge of the water intake, diet and the influence they exert, the information cryoscopy and electrical conductivity furnish may be exceedingly misleading. These methods of study are time-consuming and require expensive apparatus, skill and training on the part of the laboratory worker, and are impracticable for general use.

CHLORIDES.

Of the various inorganic salts excreted by the kidneys, sodium chloride occurs in the greatest quantity. The management of chlorides by the body is intimately associated with the water intake and output. The place of excretion of chlorides in the kidney is a matter of some dispute. Schlayer considers the tubules as being the point of excretion while experiments by Underhill, Wells and Goldschmitt[13] is seen to show that under normal conditions water and salts are passed to the glomeruli, their output to be controlled by the concentrating power of the tubules. Fitz and Schlayer distinguish two types of abnormal salt reaction. In one the added salt is retained because of the inability of the tubules to concentrate and of the failure of the glomeruli to show a diuretic reaction to the stimulus of the salt. In the other added salt is promptly excreted mainly by diuresis because the glomerular mechanism is hypersensitive and promptly reacts. Inability of the kidney to excrete salt is followed by chloride retention and consequently water retention resulting with edema. The relation of salt retention to edema has been conclusively demonstrated by Vidal and many others and great emphasis has been laid upon the study of chlorides in nephritis. There may be retention of chlorides without retention of nitrogen or without any disturbance of function, as indicated by the excretory tests, the chloride retention being the only indication of kidney insufficiency. The clinician can readily recognize chloride retention as the edema, and when not due to vascular or cardiac cases may be used as an index. Bayne-Jones[2] discusses the various clinical methods of salt estimation.

ACIDOSIS.

The body fluids are kept at a neutral and nearly constant reaction, although the production of acids in the course of body metabolism is greatly in excess of the basis. This neutrality has been maintained through the excretion of the acid excess by the kidneys. Under certain pathological conditions acids accumulate in the blood and tissue and produce a symptom-complex known as acidosis. The etiology of acidosis of renal disease is not clear. The acids accumulate not so much from the overproduction as from non-excretion by diseased kidneys. With advanced renal impairment disturbance a retention of acids apparently occurs along with a disturbance in the excretion of other substances, and these acids gradually accumulate in the body, using more and more of the bases for neutralization until the bases are seriously depleted and the acids come to be in excess. Henderson and Palmer in an extensive study of the hydrogen ion content of the urine in nephritics did not find an average below normal, but slightly above the normal, and patients with fatal uremia still excreted salts so long as they excreted water. The excretion of acid salts would seem to be one of the last functions of the kidney to be lost. The recognition of renal acidosis is of great importance in prognosis and treatment.

THE VALUE AND LIMITATIONS OF FUNCTIONAL AND RENAL TESTS.

In ascertaining the functional capacity of the kidney, judicious selection of tests is the key to the maximum amount of information from the minimum expenditure of time and energy. The number of tests is now so large that it is impossible to utilize all in any individual case. It is unnecessary, moreover, since all of the available information is forthcoming at times from a single test or from a proper combination of a small number of tests. In order that the proper selection may be made, however, an insight into the value, limitations, advantages or disadvantages, peculiarities and significance of the findings, together with intimacy, with technic concerned, is essential.

On account of the approximate parallelism in the excretion of the members of the dye group, only one need be employed, and on account of its proved superiority the phenolsulphonephthalein should be selected. Of the other excretory tests, certain ones prove of value in relation to certain types of renal disease, and will be later indicated.

In order to make evident the peculiarities in value and limitations of these various tests it is advisable to consider them in relation to three great types of renal disease: (1) unilateral and bilateral diseases necessitating ureteral catheterization; (2) bilateral surgical diseases secondary to obstruction in the lower urinary tract, and (3) medical diseases of the kidney.

1. In the first group it is desirable to have information in regard to three phenomena: (*a*) the total or combined renal function without ureteral catheterization; (*b*) the relative function, and (*c*) the absolute functional value of each kidney.

The phenolsulphonephthalein test is incomparable so far as total function is concerned and gives information frequently unavailable from any other source. In cases in which leakage and inhibition are absent, it furnishes in itself all of the necessary information in regard to the function of each kidney. In cases in which its excretion is markedly decreased, one or another of the retention tests should be employed.

The employment of functional tests in association with ureteral catheterization is attended with two great difficulties which in certain cases make it impossible always to obtain all desirable information from any one test, namely, inhibition of function and leakage around the ureteral catheter.

Any discrepancy due to inhibition can be detected readily through the determination by phenolsulphonephthalein of total renal function without ureteral catheterization. Unfortunately the inhibition is not always equal on each side and one under such conditions is not justified in accepting the phenolsulphonephthalein or total urea from each side as the true index of the relative value of the two kidneys. In this connection diastase and urea percentage, together with a difference in the intensity of the urinary pigment and a consideration of the total phenolsulphonephthalein, are of value. Indeed, it is in this connection that urea percentage finds its greatest usefulness.

In order to obtain an accurate quantitative estimation of the function of each side it is necessary to secure complete collection of the urine. By the use of Albarran's flute-end catheter it is usually possible. In a certain proportion of cases, especially in patients with relaxed ureters, leakage does occur and sometimes in amounts sufficient to nullify the findings. Unless one repeats the catheterization which is not always practicable, using the Garceau catheter on one side with transvesical collection on the other, knowledge of the relative functional values must be largely obtained from urea percentage, diastase and time of appearance of the phenolsulphonephthalein.

The peculiar value of urea percentage and diastase can be briefly stated. When inhibition occurs, the urea percentage and diastase have equal significance, but when secretion is free and leakage occurs, diastase is more reliable since it is not so readily affected through dilution. Phloridzin has proved of comparatively little value in our experience and adds practically nothing to the information obtainable from the other tests.

2. In the bilateral surgical diseases secondary to obstruction in the lower urinary tract, information concerning the total function alone is necessary. So far as excretory function is concerned only the phenolsulphonephthalein test is necessary. It is capable of differentiating

between those cases with severe renal damage and those in which the involvement is slight. It is further capable of demonstrating a marked improvement in the renal condition following appropriate preliminary treatment and enables the surgeon to determine the cases suitable or unsuitable for operation and to select the most favorable time for surgical intervention. The urine output, urea and total solids may be practically normal and yet the patient may be on the verge of renal failure which would certainly be precipitated by a radical surgical interference.

Other tests, most of them of recent introduction, have likewise proved of but little value. Lactose fails to appear at all in the majority of these cases, in this respect, closely resembling the absence of glycosuria following the administration of phloridzin. From either of these tests an exaggerated idea of the functional derangement is almost invariably conveyed.

Diastase usually indicates decreased function when it exists, but is not a reliable index to the extent of the functional injury. It yields no additional information and consumes more time than a phenolsulphonephthalein test, and hence can be discarded.

In this group of cases tests of retention are of great importance and one of them at least should be employed in every instance in which the phenolsulphonephthalein excretion is low. They all carry about equal significance, although the parallelism of the findings has not been sufficiently investigated. Urea and total uncoagulable nitrogen parallel each other, so that only one need be employed, preferably urea determined by Marshall's method. It would seem probable that the blood urea will furnish earlier evidence than cryoscopy. There have been 3 cases in our studies in which a high urea blood content was present with a normal or practically normal freezing-point. In all three, clinical and other functional studies indicated severe renal damage. In one of these cases, with evidence of rapidly decreasing renal function, the freezing-point subsequently decreased proportionately, but the first indication of cumulative phenomena was furnished by the urea.

3. Studies of renal function in medical cases fall into two great groups: (*a*) those attempting to differentiate between tubular and glomerular involvement and (*b*) those attempting to determine total function.

The glomerular function, according to Schlayer, is indicated by the excretion of water and lactose and that of the tubules by salt and potassium iodide. Lactose and potassium iodide both being substances foreign to the body and hence not so easily influenced by extrarenal factors, were considered to be more reliable than water and salt.

Schlayer and his co-workers, from their studies with lactose, water, salt and iodide tests, have attempted to divide nephritis from a purely functional point of view into four groups, namely, purely vascular, vasculotubular, tubulovascular and purely tubular. This classifica-

tion has not been adopted by us for the following reasons: The evidence to be found in the literature for the assumption that lactose is chiefly excreted through the glomeruli is not convincing, and experiments carried out on the frog's kidney have demonstrated beyond doubt that the tubules are capable of excreting lactose. Our studies have led us to the conclusion that the potassium iodide test, as used by Schlayer, in which he has placed greatest confidence for indicating tubular functional capacity, is unreliable. We have not encountered any cases of pure tubular nephritis. When both systems are involved we do not feel that the tests can determine whether the tubular or vascular injury is preponderant. Mild passive congestion alone in many instances produces the same functional picture which Schlayer describes as characteristic of vascular nephritis. Consequently, a combined functional and clinical study is essential in order to differentiate two functionally similar but clinically different conditions.

At present so little is positively known or proved concerning the specific function of any individual part of the kidney that any attempt of the kind mentioned to divide nephritis is premature. Fundamental work in the physiology, involved in the secretion of substances by specific parts of the kidney, rather than the building up of a clinical superstructure on a questionable physiological foundation, is more likely in our opinion to lead to a deeper insight into nephritis.

TOTAL RENAL FUNCTION.

Doubt no longer exists concerning the ability of tests to reveal the total functional value of the kidneys. After attempting to correlate clinical and pathological findings with the results of functional tests as simply and comprehensively as possible, the medical cases have been divided as follows: (1) cases clinically suspected of nephritis, but exhibiting practically normal renal function; (2) mild cases of nephritis without cardiac decompensation; (3) advanced nephritis without cardiac decompensation; (4) cardiorenal cases, and (5) chronic passive congestion in cardiac cases unassociated with nephritis.

In the first group, all of the tests showing a normal function, reconsideration of diagnosis becomes necessary. In cases of mild nephritis without cardiac decompensation, a normal or practically normal phenolsulphonephthalein is sometimes encountered, together with a delayed lactose excretion. These cases Schlayer would consider as a vascular type of nephritis on account of the delayed lactose excretion and the presence at times of a vascular hyposthenuria, as indicated by the study of salt and water metabolism. An identical functional picture as regards phenolsulphonephthalein and lactose may, however, be encountered in mild passive congestion of the kidneys. The lactose test may be accepted as an index of vascular disturbance, but a decreased lactose does not necessarily mean a glomerular nephritis. With a normal phenolsulphonephthalein output, tests of retention are not necessary.

In cases of advanced nephritis, the phenolsulphonephthalein is decreased, according to the severity of the lesion. Lactose is invariably delayed in this group of cases, and its total suppression is of considerable prognostic significance, in contrast to its lack of prognostic value in obstruction in the lower urinary tract.

The salt test should be utilized in all severe cases, whether edema be present or not, in order to determine the capacity of the kidney to excrete salt as well as the effect on the quantity and concentration of the urine, but it should be used cautiously. The total diastatic content of the urine is usually decreased, but the extent of its decrease is not always proportional to the amount of functional injury. In all cases of severe nephritis, one or more of the tests of retention should be employed, their findings, together with the phenolsulphonephthalein, being depended on for prognostic indications. Cumulative phenomena are frequently encountered and when present add to the seriousness of the prognosis.

In cardiorenal cases combined functional and clinical studies are necessary in order to determine the relative responsibility of the heart and of the kidneys for the existence of the symptom-complex. Repetition of the tests is almost invariably necessary. In the presence of severe clinical symptoms the finding of a good phenolsulphonephthalein output, along with the absence of cumulative phenomena, point to the heart as the responsible factor.

Low phenolsulphonephthalein output, together with cumulative phenomena, indicates a severe lesion of heart or kidneys, or both, and in any instance a serious prognosis. A low output of phenolsulphonephthalein persisting after marked improvement in the cardiac condition, indicates serious renal disease.

In broken compensation, unassociated with nephritis, lactose is always delayed, perhaps markedly. Diastase content of the urine is low. The phenolsulphonephthalein, except in the severest types of congestion, is surprisingly good, while cumulative phenomena are practically never encountered. In cases in which the phenolsulphonephthalein output is low, with the first indication of cardiac improvement it immediately rises.

By means of these various functional tests, together with clinical studies, it is possible to obtain a much clearer conception of the renal condition than from clinical studies alone.

In severe renal or cardiorenal disease, associated or not with edema, the application of the salt test is of great importance.

It has been found that there is an exceptional type of case showing edema, albumin and casts, in which the general function is normal except for salt; indeed, a hyperpermeability may exist for other substances, the salt alone being delayed in its excretion.

The results of the test supply indications as to the amount of salt advisable in any individual case.

UREMIA.

Uremia is a clinical condition, a syndrome, resulting from renal insufficiency from any cause. Its appearance is often sudden and unexpected; its course, acute and severe, rapidly ending in death; or chronic, lasting through months. Through functional studies it is possible to ascertain that it is impending, even when no indications whatever of its proximity are revealed by the clinical study. With a continued failure on the part of the kidney to excrete phenolsulphonephthalein, lactose, etc., associated with the continuous, marked and increasing accumulation of urea or total incoagulable nitrogen or low serum freezing-point, one is perfectly safe in predicting the early appearance of uremia regardless of the underlying pathological condition.

It must be remembered, in interpreting results of functional studies, that identical functional pictures carry very different prognostic significance in different clinical and pathological conditions. Extremely low functional capacity in chronic nephritis means death, whereas in obstruction in the lower urinary tract with urinary retention and back pressure the injury may be mostly functional or temporary, so that following appropriate treatment a fair or good capacity is again established.

Functional studies always find their greatest value when associated with careful clinical studies and, when properly employed, yield most valuable information from the point of view of diagnosis and prognosis and in the selection of the lines of treatment.

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CHAPTER XI.

ANOMALIES OF KIDNEY. HYDRONEPHROSIS. MOVABLE KIDNEY. INJURIES OF THE KIDNEY.

By J. BENTLEY SQUIER, M.D.

In the following discussion of the anomalies of the kidney, frequent reference will be found to strictures and processes of growth and development whose relation to the matter in hand would not be clear without a somewhat detailed knowledge of the entire embryonic history of that organ. Then, too, the conditions of abnormal mobility and hydronephrosis are in many instances traceable directly to alterations in structure occurring in embryonic life, as well as to adult anatomical conditions, both normal and abnormal. It is thought well, therefore, to preface the consideration of the pathological conditions covered in this chapter by a brief review of the embryology and of the anatomical relations of this organ.

The development of the kidney is a most complex process, and is so closely interrelated with the development of the organs of reproduction, especially through the earlier stages, that it is desirable to begin with a consideration of the embryological history of the urogenital system as a whole. Following the impregnation and segmentation of the ovum, and the formation of the three primary germ layers, there occurs a grouping and differentiation of the cells composing the ectoderm, mesoderm, and endoderm to form the anlagen of the developing organs of the body. The organs of excretion and the internal organs of reproduction arise together from the middle or mesodermic germ layer in two groups of cells, known as the *intermediate cell masses.* In the earliest stages of embryonic growth, certain of the mesodermic cells lying between the ectoderm and endoderm multiply and group themselves as two lateral plates which come to lie on either side of, and parallel with, the depressed and thickened area of the ectoderm, known as the medullary groove, the anlage of the central system. These lateral plates are further marked off by longitudinal grooves differentiating thick median portions called the ventral mesoderm. The groups of mesodermic cells not concerned in this particular differentiation, and which lie directly beneath the longitudinal grooves, are the intermediate cell masses. These cell groups in turn become thickened, and in the embryo may be demonstrated as forming longitudinal ridges of mesodermic cells or mesenchyme projecting into the dorsal portion of the celom or body cavity. These are the Wolffian

ridges, and are concerned chiefly in the development of the excretory organs. Later, secondary longitudinal ridges, called the genital ridges, appear on the mesial surfaces of the Wolffian ridges. From them the ovaries and testes arise.

Following the differentiation and rearrangement of the cells of the mesodermic layer described above, the process directly concerned in the formation of the kidneys begins. The complexities and peculiarities of this process exceed those of any other system in the body. Three distinct sets of organs, pronephros, mesonephros, and metanephros, appear in succession. After passing through stages of development which in the lower forms of animal life represent functionating organs, in the human embryo the first two sets undergo regressive changes

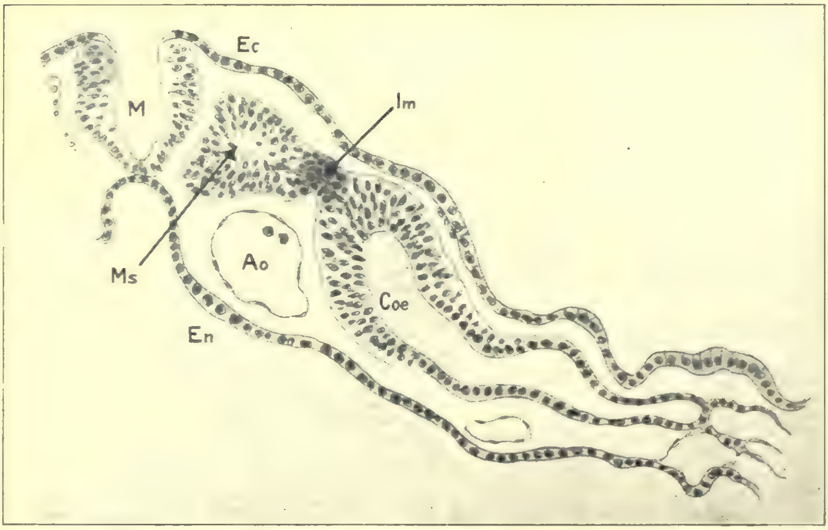

FIG. 152.—Section through embryo showing germ layers and position of intermediate cell mass: *Ec*, ectoderm; *En*, endoderm; *Ms*, mesodermic somite; *M*, medullary groove; *Ao*, aorta; *Coe*, coelum.

and disappear with the exception of certain of their elements which progress to more or less complete development and play an important part in the formation of certain portions of the reproductive organs and to a less degree, of the permanent excretory organs. The more rudimentary structures and vestigial remains are found, even in adult life, associated chiefly with the reproductive organs.

Early in the development of the embryo as a whole there is a segmental differentiation of the primary cell layers, shown best by the marking off of the mesodermic somites. These are formed by a transverse division of the median portion of the lateral plates of the mesoderm into segments. This process starts in the cervical region and extends posteriorly, resulting in the formation of thirty-eight pairs of

somites. Corresponding with this process of segmentation there is a similar transverse marking off of the intermediate cell masses from before backward as far as the tenth segment. Posterior to this segment the transverse division is not present, but the Wolffian ridge extends as a continuous column of cells known as the *nephrogenic cord.* At the region of the third or fourth lumbar segment there is a partial interruption of this cord which marks the division between mesonephros and the latter developing metanephros. In the newly formed and segmentally marked off Wolffian ridges, aggregations of cells that are at first solid cords lying in the centre of each segmental mass begin to develop a lumen. The process begins anteriorly in the cervical region, and by a process of fusion these cavities become continuous and form the two *pronephric ducts* which run backward close under the ectoderm and open into the cloaca. About the same time, and as the

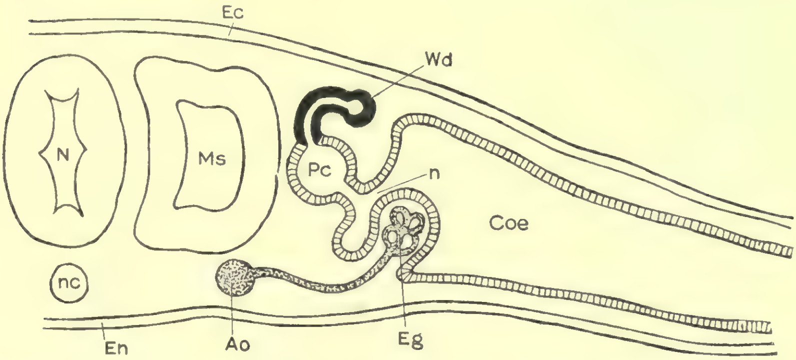

FIG. 153.—Diagrammatic section through pronephric structures: *Ao,* aorta; *Coe,* celum; *Ec,* ectoderm; *Eg,* external glomerulus; *En,* endoderm; *Ms,* mesodermic somite; *N,* spinal cord; *n,* nephrostome; *nc,* notochord; *Pc,* pronephric chamber; *Wd,* Wolffian duct. (McMurrich.)

result in all probability of evaginations of the cells of the intermediate cell masses of the seventh to fourteenth segments the *pronephric tubules* are formed. These communicate with the *pronephric ducts* and with the celomic cavity. Near these latter openings, or nephrostomes, evaginations of the celomic epithelium occur, into which branches of the aorta penetrate, forming *external glomeruli.* As the formation of these tubules and glomeruli progresses backward, the more anterior ones degenerate and, in human embryos of 5 mm., they have all disappeared. The *pronephric ducts,* however, remain and, in conjunction with the development of the mesonephros, are known as the

Wolffian Ducts.—In embryos of 3 or 4 mm. in length, aggregation of some of the mesodermic cells of the Wolffian ridges forms solid cords whose ends come to lie in contact with the celomic epithelium and with the Wolffian ducts. Lumina are formed and the resulting tubules acquire communication at their outer ends with the

Wolffian duct. At their inner ends, now free from contact with the celomic epithelium, small masses of mesodermic cells accumulate and branches from the aorta enter among them and form *internal glomeruli*. The walls of the tubule come to envelop the glomeruli except at the point where the vessels enter; the whole structure forming a Malpighian corpuscle. The tubules become elongated and convoluted, and

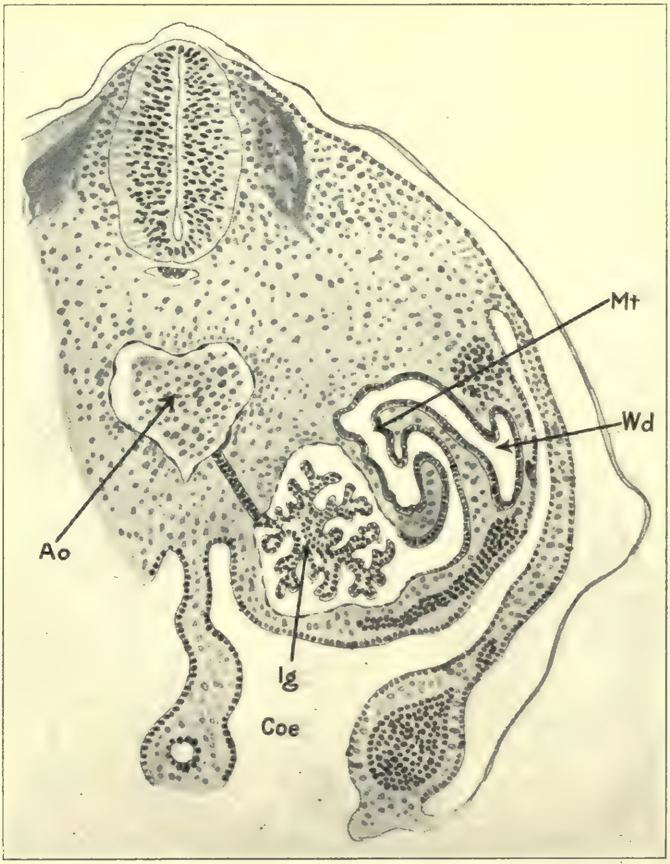

FIG. 154.—Section through mesonephric structures: *Ao*, aorta; *Ig*, internal glomerulus; *Mt*, mesonephric tubule; *Wd*, Wolffian duct.

excretory function is carried on. This process begins in the region of the fifth or sixth cervical segment, and extends to the third or fourth lumbar segments. In the posterior portion of the Wolffian ridges, that is, posterior to the tenth dorsal segment, where a marked proliferation of the tubules occurs, the so-called Wolffian bodies, which are of considerable size, project markedly into the celomic cavity, and have a distinct mesentery.

Just as in the pronephros, the anterior tubules of the mesonephros degenerate as the more posterior ones are forming, so that in embryos of 21 mm. only the ones belonging to the lumbar segments remain. At about the sixteenth week only the ducts and rudimentary portions of the mesonephric tubules remain to form accessory parts of the reproductive apparatus. The ducts become the vasa deferentia, ejaculatory ducts, and seminal vesicles in the male, and Gärtner's canals in the female, while the tubular structures form the efferent

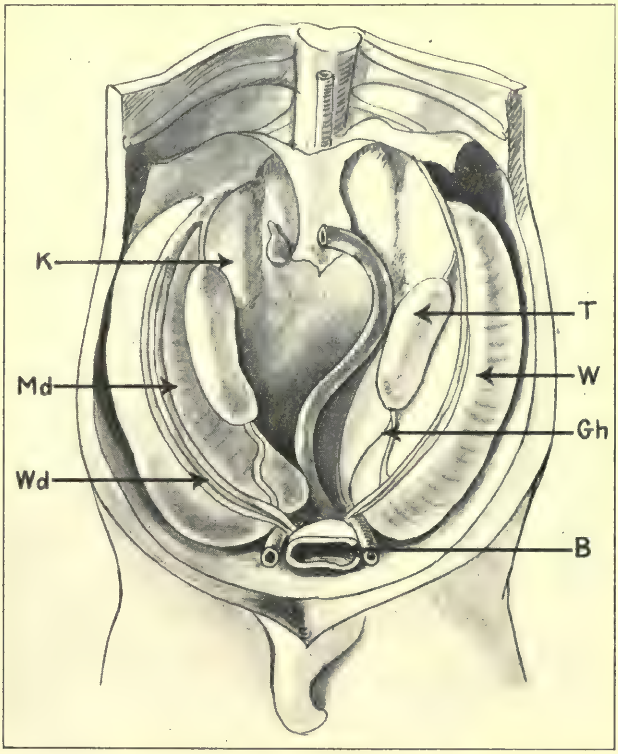

Fig. 155.—Urogenital apparatus of male pig embryo of 6 cm: *K*, kidney; *Md*, Müllerian duct; *Wd*, Wolffian duct; *B*, bladder; *T*, testis; *Gh*, Gubernaculum testis; *W*, Wolffian body. (Mihalkovicz.)

ducts, vasa aberrentia, and paradidymes in the male, and the epoophoron and paroöphoron in the female.

The third and final stage in the embryonic history of the excretory organs is the development of the metanephros, or permanent kidneys. Before the degenerative changes in the mesonephros have involved the region of the lumbar segments, namely, at about the fourth week, in embryos of 5 mm., a hollow, bud-like outgrowth, the *renal blastema*, appears on the dorsal surface of each of the Wolffian ducts near their

entrances into the cloaca and projects into the cell mass of each of the Wolffian ridges in that portion which lies posterior to the region concerned in the formation of the mesonephros, known as the *metanephric blastema.* The two evaginations, which come to lie laterally to the Wolffian ducts, continue to elongate cranially and take the form of narrow hollow stalks which become the *ureters,* and dilated germinal portions which divide into distinct cephalic and caudal branches and mark the *primary renal pelves.* These branches are surrounded by caps of the metanephric blastema in which two zones of cells may be dis-

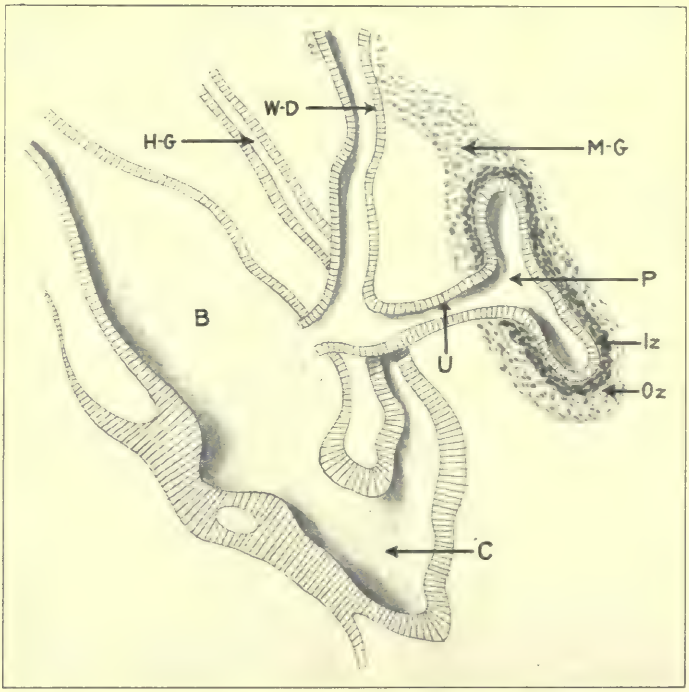

FIG. 156.—Primitive pelvis of the kidney, showing origin of permanent kidney: *P*, pelvis of kidney; *U*, ureter; *M-G*, metanephric blastema; *Iz*, inner zone cells; *Oz*, outer zone cells; *H-G*, hindgut; *W-D*, Wolffian duct; *B*, bladder; *C*, cloaca. (After Schreiner.)

tinguished, an inner or epithelioid, and an outer or mesenchymatous zone. The latter forms the supporting structures, while the former becomes the excretory portion of the kidney. The *collecting tubules* are formed up to the fifth month by a series of three to six tubular outgrowths from the primary pelvis and by the subsequent dichotomous division and subdivision of these outgrowths for a series of between eleven and thirteen generations. The primary pelvis and the tubules of the first four generations enlarge to form the final contours of the *renal pelvis.* The enlargement and fusion of the proximal ends of the tubules of the first generation form the *calices majores,* while those of

the second generation by fusion with those of the third and fourth form the *calices minores*.

As each outgrowth from the primary pelvis occurs the inner zone of the cap of metanephric blastema divides simultaneously and comes to form separate caps about each new ampulla. All the subsequent divisions are accompanied by a similar process, so that finally each terminal collecting tubule is surrounded by its own cap of inner zone cells. These cells condense to form a solid mass, the *renal vesicle*, which becomes attached to its corresponding terminal tubule and later acquires a lumen continuous with that of the tubule. It then elongates into the form of a letter S. In the hollow formed by the distal dilated

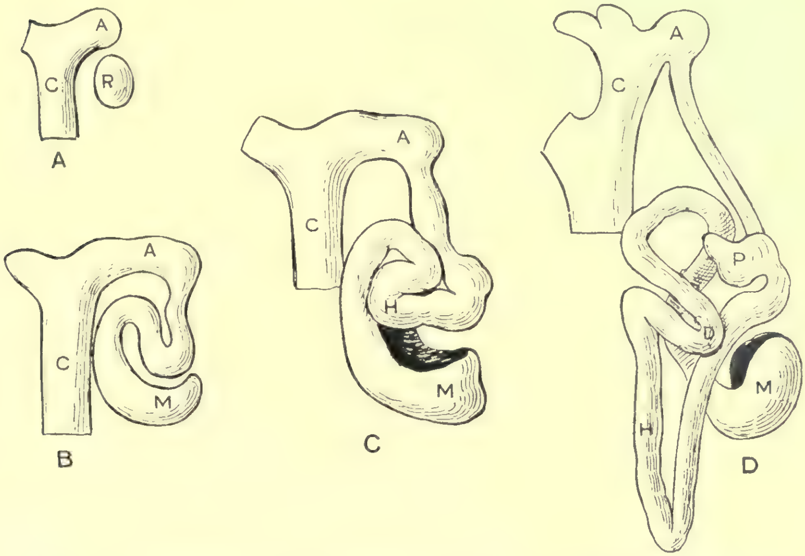

FIG. 157.—Development of a uriniferous tubule of a cat: *C*, collecting tubule derived from renal bud; *A*, ampulla; *R*, renal vesicle derived from metanephric blastema; *M*, Bowman's capsule portion of glomerulus; *H*, loop of Henle; *P*, proximal convoluted tubule; *D*, distal convoluted tubule. (After Huber and McMurrich.)

loop of the S there is a condensation of the mesenchyme into which a branch from the renal artery penetrates and divides up into capillaries to form a *glomerulus*. The tubular structure thins out and comes to envelop the glomerulus which is finally surrounded, except where its vessels enter and leave, by two layers of the tubular epithelium. The inner layer is greatly thinned and lies in contact with the glomerulus, while the outer layer constitutes the *capsule of Bowman*. The proximal loop of the S elongates parallel with its collecting tubule to form a *loop of Henle*. At about the fourth month the *proximal convoluted* portion of the fully developed tubule lying between the glomerulus and the descending limb of the loop, while the *distal convoluted* portion

of the tubule and the arched collecting tubules are formed by that portion of the tubule lying between the ascending limb and the terminal collecting tubule which, as we have seen, is a derivative of the Wolffian duct. The formation of tubuloglomerular units begins in embryos of about 30 mm. in length and continues to the time of birth.

In the process of division of the primary renal pelvis, the mesenchyme lying between the evaginations, acting as septa, serves to divide the developing organ into lobe-like pyramids usually four in number. In a corresponding manner the secondary and tertiary divisions are accompanied by a lobe-like formation which is visible on the surface of kidneys at birth and at times persists through life. The four primary lobulations are described as cephalic, caudal and two central lobes. The former two grow more rapidly and consequently tend to encompass the pelvis, thus giving the kidney its characteristic concavoconvex form.

The kidney, as we have noted above, has its origin in the most posterior portion of the Wolffian ridge in the sacral region, and it does not advance to the permanent renal level until about the end of the second month. In the course of its migration it undergoes an axial rotation at the midlumbar level so that the pelvis is directed toward the midline instead of ventrally. The vascularization of the organ does not occur until it has reached its permanent site, and this fact will aid, as we shall see later, in differentiating abnormalities of position. The renal capsule, the supporting connective tissue of the parenchyma, and the remains of the lobular septa, are derived from the outer zone of the metanephric blastema.

The process by which the ureters, originally outgrowths from the Wolffian ducts, attain their separate openings into the bladder requires a consideration of the changes which occur in the morphology of the cloaca and the structures opening into it. The cloaca becomes divided by a septum into a dorsal and a ventral portion. The former becomes the lower part of the rectum, while the latter, receiving the allantoic stalk and the Müllerian and Wolffian ducts, is further differentiated into an upper or anterior tube-like portion, which becomes the urinary bladder, and a lower or posterior portion, known as the urogenital sinus. The point of entrance of the urogenital (Wolffian) ducts marks the division between the two portions. The vesical portion begins to enlarge at about the second month, and as it becomes more sac-like the ends of the ducts common both to ureters and Wolffian ducts are taken up in the enlargement of the wall until the points of entrance of the ureters into the Wolffian ducts are reached. As the process continues these attain a position in the bladder wall somewhat anterior and lateral to the openings of the Wolffian ducts. By the lengthening out of the wall of the sinus between the two pairs of openings the ureters come to open above into the vesical dilatation while the Wolffian ducts open below into the sinus itself. As the bladder expands the ureteral openings are further separated and the trigone is formed.

Disturbances in the foregoing process or the presence of supernumerary renal buds (ureters) explain the occurrence of anomalous ureteral openings, both intra- and extravesical.

ANATOMY OF THE KIDNEY.

Because of their position and relations the kidneys do not lend themselves readily to satisfactory physical examination. After their migration from the sacral region they come to lie behind the peritoneum deeply located in the abdominal cavity on either side of the vertebral column, between the eleventh and twelfth dorsal and the first and second lumbar vertebræ. The right kidney is, under normal conditions, situated slightly lower (about half an inch) than the left, and its lower pole is at times palpable under simple conditions of examination. Using superficial bony points as landmarks the kidneys lie between the eleventh dorsal and the second lumbar spines. Their lower boundaries are from an inch and a half to two inches above the level of the line joining the crest of each ilium and the umbilicus. The spine of the first lumbar vertebra marks the site of each hilum, which is about two inches from the midline and almost directly under the tip of the corresponding transverse process. The upper poles of each kidney are slightly nearer the midline than the lower. The outer borders of the kidneys are about three and a half or four inches from the midline.

The kidneys are in relation with the pillars and costal attachments of the diaphragm above and the quadratus lumborum muscles posteriorly, while the lower poles rest upon the outer margin of the psoas and to a slight extent the transversalis muscles. The right kidney is in relation in front with the lower and posterior surface of the liver; the descending portion of the duodenum and the lower pole is barely crossed by the ascending portion of the colon. Almost in direct apposition with the inner border is the vena cava. The upper third of the left kidney is covered in front by the fundus of the stomach, the middle third by the tail of the pancreas and splenic vessels, and the lower third by a portion of the transverse or descending colon, while the upper anterior portion of the outer margin lies in relation with the spleen. To the inner margin and about half an inch from it lies the aorta. At the upper pole of each kidney and in contact with its anterior surface are found the adrenal glands. They lie beneath the peritoneum and within the fatty capsule of the kidneys. They are relatively larger during infancy and childhood than in adult life, and have little surgical importance in connection with renal lesions, except insofar as their blood supply may be intimately associated with that of the kidney. The coils of the small intestine that lie anterior to the kidneys move freely with changes of posture, so that they offer little interference with attempted palpation of those organs.

Certain of the relations of the kidneys are well to bear in mind not

only during physical examinations, but also in the course of operative procedures. Contact with the diaphragm above and behind may, because of the projection of the pleural cavities down to the level of the twelfth rib, lead to displacement of the kidneys downward and forward in the case of accumulation of material in the cavities. Since the twelfth rib is used as the landmark in operations upon the kidney by the posterior route, absence or unusual smallness of this rib may lead to the accidental opening of the pleura with troublesome results. Furthermore, this diaphragmatic relation is of evident importance in traumatic and suppurative conditions. In differential diagnosis the location of masses in the renal region in respect to the colon must be taken into account.

The peritoneal investment of the kidneys is only partial and covers the anterior surfaces to a greater extent on the right side than on the left. The areas not so directly covered are occupied, with the exception of liver and stomach, by the organs described as being in relation with the kidneys. The peritoneum in this region is relatively thick and firm and is readily separable from the kidney in operations through the lumbar route, except when bound down by inflammatory or neoplastic processes. The toughness of the overlying peritoneum tends to prevent involvement of the general abdominal cavity in renal infections, and explains the fact that even extensive traumatic lesions of the kidney are seldom accompanied by laceration through the peritoneum into the abdominal cavity.

Since important elements of the blood and the nerve supply of the colon pass between the peritoneum and kidney, due regard must be paid to the avoidance of serious damage to the colon in approaching the kidney by the transperitoneal route. In cases of extreme motility of the kidney the peritoneal investment may become lengthened out and more nearly complete, so that it approximates the formation of a mesonephron.

The *capsule of the kidney* is thin and transparent, but relatively firm and fibrous. It is closely applied to the kidney surface, and delicate processes from it extend into the kidney substance accompanying bloodvessels and at the sites of the early lobular demarcations. At the concave border it extends as a sheath over the vessels and nerves of the organ and extends into the hilum with the subdivisions of the pelvis into the calyces. Under normal conditions the capsule is readily stripped from the kidney, leaving a smooth surface on which bleeding-points mark the site of small vessels torn in the process. While the capsule is practically inelastic it will yield to internal pressure of gradual development and may adapt itself to enormous dilatation. Pressure from within of rapid onset, however, is productive of great pain, as in obstruction of the ureter or veins, or even in the parenchymatous swelling of true acute nephritis.

Surrounding the fibrous capsule there is the so-called *fatty capsule* or perirenal fat of the kidney, made up of loose areolar tissue derived

from the subperitoneal fascia containing variable amounts of fat. This is most abundant behind, at the lower pole, along the outer border and the hilum, but is usually absent over portions of the anterior surface. At birth, during early childhood, and in old age and in general emaciation of adults the amount of fat is scanty or may be absent. The loss of the firm, supporting function of this bed of fat permits of abnormal motility of the kidney, notwithstanding the many trabeculæ of fibrous tissue, which pass from the renal fascia through the fat capsule to unite with the kidney capsule. Into this surrounding adipose tissue extensive extravasations of blood and urine, or the extension of suppurative processes, may proceed with little restriction. In addition to this perirenal fat capsule there is a layer lying behind the retrorenal layer of the renal fascia. This is known as the *pararenal fat layer*, and is encountered in operations through the lumbar route.

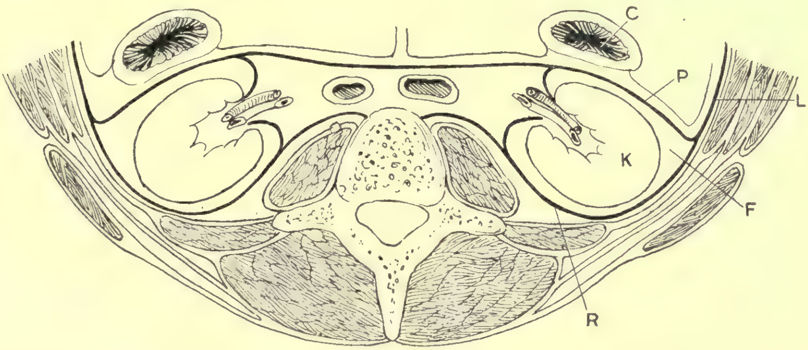

FIG. 158.—Diagrammatic cross-section through body, showing arrangement of fascial layers about kidney: *K*, kidney; *P*, prerenal fascia; *R*, retrorenal fascia; *L*, fascial layer derived from subperitoneal fascia of abdominal wall; *F*, perirenal fatty capsule.

Although lying in anatomical pockets formed by the vertebræ, ribs, lumbar muscles, and diaphragmatic attachments, the kidneys have relatively poor support, intra-abdominal pressure and their fat pads being the chief supporting factors. In addition a somewhat important supporting function is ascribed to the layers of fascia, the so-called *renal fascia*, derived from the subperitoneal fascia of the abdominal wall. This fascia divides at the outer margin and upper pole of the kidney and sends a layer, the *prerenal fascia* over the front of the kidney outside of the perirenal fat, and is continued over the renal vessels, aorta, and vena cava to unite with the similar layer of the opposite side. The posterior or *retrorenal layer* of this fascia passes between the kidney and the fascia over the muscles of the kidney bed to join the fascial covering of the vertebral column. On account of the many processes and attachments of the layers of the renal fascia its supporting function is assumed. Behind the renal fascia run the last dorsal, iliohypogastric, and ilioinguinal nerves.

At the hilum of the kidney, which is directed inward, forward, and slightly downward, are the renal vein, artery, and pelvis of the kidney. The vein lies most anteriorly. The artery lies behind and slightly above it, while the pelvis lies behind and below the former vessels. Because of the position of the kidneys relative to the aorta and vena cava the right renal vein is shorter and the right renal artery longer than the left. The renal arteries are relatively large in proportion to the size of the kidneys and accessory and anomalous arteries are common; this, together with the extreme shortness of the renal vein, materially increases operative difficulties. Before it enters the hilum of the kidney each renal artery divides into a dorsal and a ventral branch, which further subdivide within the hilum into four branches, two supplying the anterior and two the posterior half of the kidney, with little anastomosis between the vessels of the two halves in the renal cortex. This results in a relatively anemic zone, through which the cortex may be incised longitudinally with little hemorrhage, the exsanguinated zone of Hyrtl. For practical purposes this zone is described as being represented by a line one-half inch dorsal to the lateral longitudinal border of the kidney, the so-called Brödel line. However, there is a rather free anastomosis across the midline at the level of the bases of the pyramids, so that the pelvis cannot be opened through the cortex without considerable hemorrhage.

The pelvis of the kidney is that funnel-shaped enlargement of the upper end of the ureter with its apex at about the level of the lower pole of the kidney. The expanded portion enters the hilum or sinus to open out into an upper and a lower branch, from which the calyces are given off. From the apex of the pelvis to its point of entrance into the bladder the ureter is about twelve inches long. In its course to the bladder it lies directly beneath and in close association with the peritoneum. Three points of narrowing are found normally, the upper one being at the level of the lower pole, the middle one where the ureter crosses the iliac vessels, and the lower one at the ureteral orifice in the bladder. At these points calculi often find lodgment, and if the obstruction is partial or intermittent great dilatation of the ureter and the condition of hydronephrosis results.

The renal plexus furnishes the nerve supply of the kidney. Derived from the aortic and solar plexuses and from the lesser splanchnic nerves it possesses also close connection with the spermatic plexus, with the sympathetic ganglia controlling the intestines and bladder, and, through certain connections, with the lumbar nerves. Each renal plexus, because of these anatomical associations, is bountifully able to distribute irritating stimuli arising in the kidney to many diverse foci and produce a great variety of symptoms, such as nausea, vomiting, vesical and rectal tenesmus, testicular or lumbar pain. Through the close association of the sympathetic systems of each side a lesion of one kidney may produce disturbances, chiefly functional (reflex anuria) in the other. The vasomotor control of the kidney is exercised from a centre in the floor of the fourth ventricle.

METHODS OF EXAMINATION.

For the purpose of examining for the conditions treated of in this chapter advantage must be taken, in one respect or another, of practically every method of examination commonly used in the investigations of renal morphology and function. These methods included in the physical examination are *inspection*, *palpation*, and *percussion;* search for *painful points;* the *examination of the urine* from the bladder; and *cystoscopic examination* with examination of the urine from each of the kidneys separately, and the examination of the entire urinary tract by *radiography*.

Unless the kidney is markedly enlarged or a suppurative process is pointing in the lumbar region but little information can be gained by *inspection*. Occasionally in greatly emaciated individuals a movable or floating kidney, even though not markedly enlarged, may be visible and may be seen to move with respiration below the costal margin.

Palpation.—In general it may be said that in the average well-nourished, otherwise normal, individual a kidney that is not enlarged or abnormally movable is not palpable. Often, however, exceptions to this rule are found in the case of the right kidney which, because of its normal lower position and its excursion downward with the diaphragm and liver during inspiration permits the palpation of at least its lower pole. Even moderate enlargements and increased mobility do, however, render the kidney palpable when advantage is taken of the various methods of increasing its accessibility, such as postural measures and relaxation of its muscular surroundings. With the patient in the lateral prone position with knees flexed and thighs drawn up toward the abdomen, or in the half-reclining position with thighs drawn up, bimanual examination is greatly facilitated. With the patient seated in a chair, the shoulders bent forward, and the examiner seated behind or to the side, a satisfactory examination is often possible. Particularly satisfactory relaxation of the abdominal wall may be obtained by examining the patient in the half-reclining position in a tub of hot water. General anesthesia offers, of course, the best relaxation.

On account of the location of the organ *bimanual examination* furnishes most information as to the size, position and sensitiveness of the kidney (using the left hand above for examining the right side, and *vice versa*). By placing the fingers behind the loin and making compression with the thumb just below the costal margin the downward excursion of a movable kidney may be felt, and, if extreme the kidney may be fixed temporarily in the low position by continued pressure of the thumb above its upper pole.

Where palpation fails and it is essential to determine definitely the presence or absence of the opposite kidney in a case of prospective nephrectomy, direct palpation through an abdominal or lumbar inci-

sion is the only sure means of avoiding unfortunate "accidents." A most important additional safeguard is the examination of the functional integrity of the opposite kidney by ureteral catheterization. Either of these procedures if used alone is capable of leading to erroneous conclusions. A kidney apparently normal to palpation, so far as size and contour and apparent consistency are concerned, may have decidedly deficient functional activity, or by reason of an anomalous course or vesical opening the results of ureteral catheterization may at times be unpleasantly misleading.

Percussion.—Percussion yields but little information in regard to the kidney itself, but it is of decided value in ascertaining the relation of a given mass in the renal region in respect to the surrounding organs, particularly the colon, and so aiding in the differential diagnosis, except in cases of retroperitoneal growths in that region.

By reason of the extensive nervous connections of the kidney the question of referred pain, as well as the actual degree of sensitiveness of the kidney itself, is of diagnostic importance. In a healthy state the kidney is comparatively non-sensitive to palpation, or at most responds with a sensation resembling the testicular. The presence of retention, strangulation, a suppurative process, calculus, or in some instances, a tumor, increases the *pain sense* to a marked degree, during attempts at ballottement (Guyon) or on pressure along the lower margin of the last rib, as well as during the ordinary examination by palpation. Certain definite *pain points* are recognized as indicating lesions in the kidney. These are demonstrable as follows: over a point opposite the umbilicus in a line drawn vertically through McBurney's point; a *costovertebral point* lying in the angle formed by the last rib with the vertebral column; a *costomuscular point* lying more anteriorly in the angle formed by the last rib and lumbar muscle group; and a point above and just to the inner side of the anterosuperior spine of the ilium near the exit of the femorocutaneous nerve. Lastly, pressure through the vagina on the base of the bladder near the entrances of the ureters elicits considerable pain, and occasionally induration and thickening of the ureter may be felt. The presence of these painful points is indicative more particularly of inflammatory lesions of the kidney, renal pelvis and ureter.

While *examination of the urine* from the bladder does not exclude lesions of that organ itself, the presence of blood, microörganisms, pus, gravel, fragments of tumors, etc., in conjunction with localizing symptoms in the region of the kidneys, is of marked value, particularly in indicating the line for further investigation. Small cylindrical clots of blood conforming to the shape and size of the ureter as a rule indicate renal hemorrhage. A purulent urine without the presence of the usual pyogenic bacteria suggests tuberculosis.

Cystoscopic Examination.—Cystoscopic examination of the bladder with investigation of the ureteral orifices and catheterization of the ureters offers the most valuable facts of diagnostic significance. The

technic and instruments used in this work are described in another chapter. However, the significance of certain of the findings will be referred to in the diagnosis of the lesions covered in this chapter.

Radiography.—Radiography of the urinary tract, especially when performed with styletted or *x*-ray opaque ureteral catheters *in situ* or after filling the renal pelvis with collargol or thorium solution, is of the utmost diagnostic value in determining the presence of renal and ureteral anomalies, postnatal malformations or misplacements, and often reveals the existence of calculi and tuberculous or advanced suppurative processes. The investigation of lesions of the urinary tract by this injection and radiographic method has come to be known as *pyelography*. The details of this work are treated elsewhere.

ANOMALIES OF THE KIDNEYS.

The frequency with which anomalies and congenital malformations are encountered in operations upon the kidney and ureter renders familiarity with the type and nature of the more common abnormalities of this sort essential to the surgeon. An appreciation of the extensive possibilities of variation that result from arrested or faulty development can be obtained when the extreme complexity of the process by which the organ develops is considered. We have therefore embodied in this chapter a brief review of the embryological history, together with a short consideration of the adult anatomy and relations of the kidney and ureter, in order that the origin and nature and pathological significance of the abnormal conditions discovered clinically may be better understood.

In general, the anomalies of the kidney may be grouped as those of number, of form, and of position. With these must be grouped also those embryological alterations in more minute structure, which are present at birth but which often do not reach their full development until later in life, such as congenital cystic kidney and the tumors resulting from the growth of adrenal rests included within the kidney substance. The anomalies of the ureter are of course inseparably associated with those of the kidney, and constitute the most frequent and important congenital abnormalities found in the urinary tract. They consist chiefly of variations in the number and in the nature and location of their openings below.

Anomalies of Number.—The variation in number may be one either of *deficiency* or of *excess*. Total absence of both kidneys of course presupposes a non-viable monster. Congenital absence of one kidney and its compatibility with life was known to the ancients. Complete failure of the renal bud to develop at the base of the Wolffian duct or its early blighting may account for most of these cases, but it has been found that in a small group, although there was entire absence of the kidney, a short or rudimentary ureter was present. This would presuppose a failure of development of the metanephric blastema after

the renal bud had developed considerably. The possibilities of this latter group in causing wrong conclusions from cystoscopic examinations where actual catheterization of both ureters was not accomplished must be borne in mind. Absence of one kidney occurs about once in each 2500 cases, it is twice as frequent in males, and is more often upon the left side. This condition is often accompanied by malformations of the genitalia, particularly in women. Of considerable importance is the ureteral condition in these cases. If a double ureter with two vesical openings is present the openings are on the same side. A case is reported in which a single ureter crossed from a right-sided single kidney and entered the left side of the bladder. In the complete absence or arrested development of a kidney the one present is nearly always enlarged (compensatory hypertrophy), and having to carry a double functional burden, is often the seat of pathological changes. Nephrectomies have been performed on such organs with fatalities in from one to eleven days. A kidney of unusual size whenever encountered should suggest the possibility of the absence of the opposite organ. In considering these cases of congenital absence of one kidney one must not confuse the remaining or single kidney with those cases of solitary kidney which are the result of fusion of the renal anlagen and belong to the group comprising the anomalies of form. With the cases of congenital absence of a kidney may be grouped those more frequent cases of arrested development of one or both kidneys which show rudimentary or atrophic organs. Such congenital malformations may be divided into two classes, the first comprising the kidneys that are represented by fibrous masses of tissue often containing cyst-like cavities, but showing no renal parenchyma, and the second including those in which, though renal parenchyma is present, the microscopic histology is imperfect; tubules but no glomeruli being found. In such cases also the ureters may be imperfectly developed, no lumen being present, or else it is patent only for a short distance toward the kidney. In some cases the kidney may be found to have developed to the stage of functional activity, but because of a lack of outlet for the urine it undergoes cystic dilatation. Such a condition due to a thin cord-like state of the upper third of the ureter was found at autopsy in a child, five weeks old, and showed a cystic kidney about one-half the size of the opposite organ. The cysts corresponded in number and arrangement with the fetal lobulation. In an embryological sense to this group belongs the so-called congenital cystic kidney, which represents, according to the more generally accepted theory of origin a development of functional glomeruli and tubules, but an imperfect union between a variable number of the anlagen of the glomerulotubular structures and the anlagen or the straight or collecting tubules which arise from the renal bud. The condition is practically always bilateral; it may be marked and fatal shortly after birth, or in a less severe type the case may go on well into adult life before the condition is discovered.

Arrested development may result in an organ of small size, but with-

out other structural or functional faults. The least important congenital malformation that can be ascribed to arrested development, a condition rather frequently seen, is persistence of the fetal lobulation. These kidneys, as well as the more definitely malformed organs, are peculiarly susceptible to disease, such as tuberculosis, suppuration, and stones. Defects in the development of the bladder and genitalia frequently accompany those of the kidney and ureters, particularly in the female. Pelvic organs of the infantile type, or absence of tube and ovary of the same side, and malformation of the vagina and uterus are the more common examples of this.

The diagnosis by palpation of congenital absence or imperfect development of a kidney is extremely difficult, except in very rare instances. Cystoscopy and pyelography, with examination for the amount and the chemical content of the secretion of the two sides obtained by catheterization of the ureters, offers the most satisfactory means of determining the existence of such conditions. These measures should always be employed when nephrectomy is contemplated, for the list of cases in which the only efficiently functional kidney has been removed is unfortunately long.

Developmental *defects of excess* are extremely rare so far as the kidneys themselves are concerned. Many of the cases reported as supernumerary kidneys are found on analysis to be in all probability merely examples of unusual forms of fusion anomalies or of peculiar division of the original renal bud with consequent separation of the blastemic cap, rather than of true supernumerary organs with separate ureter and blood supply. Kidneys with two or more ureters separate throughout their entire length, leading from separate pelves, and opening separately into the bladder, are relatively common. These forms will be discussed under anomalies of the ureters.

Anomalies of Form.—Abnormalities in the shape of the kidney are due in the majority of instances to the so-called *fusion variations.* The renal buds with their caps of metanephric blastema, instead of developing into separate and distinct kidneys and progressing normally, separate into their adult location, come into contact across the midline and undergo a union of their metanephric substance. This union usually occurs ventral to the aorta and cava in the region corresponding to the lower poles of two kidneys. Occasionally, however, the point of fusion is at the upper poles or even dorsal to the great vessels. As a rule the further development of the two renal buds is symmetrical, but the progress upward of the kidneys to the usual level is generally interfered with by the connecting bar of tissue, and the axial rotation is often incomplete, so that the ureters and vessels come off from the organs from their more ventral aspect. The area of fusion may consist of mere bands of connective tissue or may be made up of a massive segment of gland tissue. This type of fusion constitutes the so-called "horseshoe" kidney—a type of anomaly found once in each 1100 cases. (Küster.)

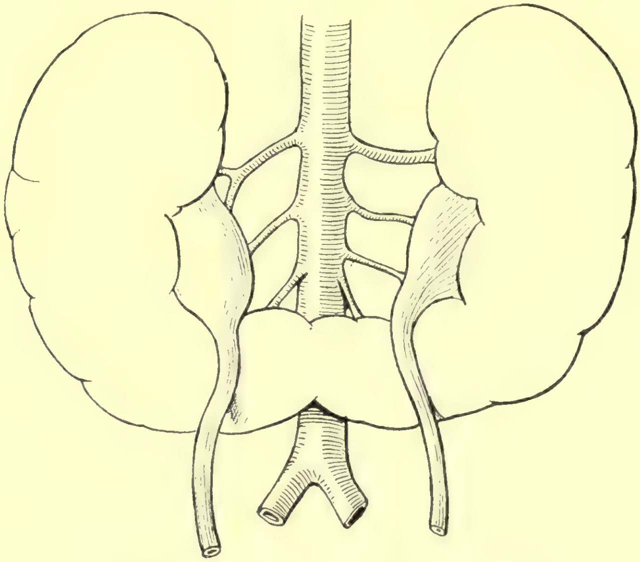

Fig. 159.—Horseshoe kidney. Isthmus below.

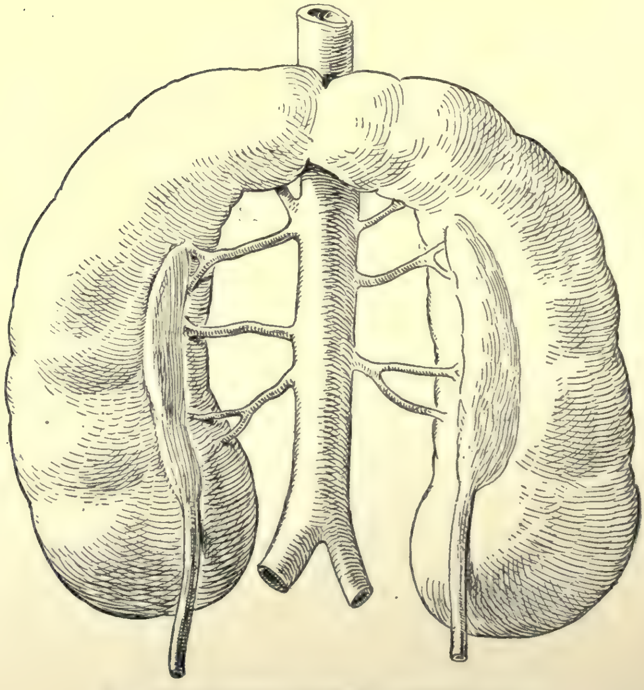

Fig. 160.—Horseshoe kidney. Isthmus above.

When one renal bud is given off from the Wolffian duct higher up than the other, or if the growth of one bud is more rapid before fusion occurs, the bridge thus formed usually joins the lower pole of one kidney with the upper pole of the other, and the resultant "long," or tandem kidney, usually lies on the side normally occupied by the upper unit. In such cases there are usually two pelves and two ureters which open separately in the bladder, the one from the lower kidney having of necessity to cross the great vessels to reach its normal outlet. Rarely do both ureters enter the bladder on the same side. A more complete type of fusion along the entire mesial border is found in the rare cases of rounded or flattened kidneys. This variety of fusion kidney lies in the midline and each component enjoys its own blood supply and ureter. A further type is the so-called formless kidney which is made up of a mass of irregular lobules of gland tissue. The presence of two ureters indicates the probability of its being a fusion anomaly. Recognition of the presence of horseshoe kidney, or of the other less common forms of fusion anomalies, is rarely possible before operation or autopsy. There is nothing in the condition itself that precludes normal functionation. A palpable kidney in the midline transmitting impulses from the aorta, together with radiographs showing irregularities in the outlines of the renal pelves or reduplications of the ureters, strongly suggests the probability of such an anomaly. Owing to the fact that such organs are usually situated below the normal kidney region and may extend as low as the pelvic brim, they do occasionally act as an impediment to labor.

Like the kidneys of hypoplastic type, the organs showing fusion anomalies seem to be more liable to diseases such as tuberculosis, suppurations, and various types of cystic degenerations. The literature contains descriptions of operations in which portions of compound kidneys on either or both sides have been resected or stones have been removed from the different segments. The irregularities of form and position tend to produce pressure on the veins and ureters. Anomalies of the vascular supply and of the pelves and ureters are the rule with kidneys showing anomalies of form.

Anomalies of Position.—In the course of its migration upward from the level of the second sacral vertebra to the normal position with its hilum at the level of the second lumbar vertebra some error of development may occur to arrest the progress of the kidney and determine an abnormal permanent location. Since the vascularization of this organ does not occur until it has reached its permanent abiding place, it naturally follows that the vessels given off from the regional vascular trunks serve to fix the kidney in its abnormal position. It may be said then that a kidney fixed in an abnormal position is, in the great majority of cases, a congenital condition. The possible exceptions are those instances where inflammatory processes have bound down in an abnormal position a kidney having an acquired motility. These will be discussed in the section on movable kidney.

It has been noted above that malformed kidneys, especially those of the fusion forms are usually also misplaced, and generally to the most marked degree. Malformations of the genital tract are a frequent accompaniment of this condition. A few cases of misplacement of but one of the kidneys, usually the left, are recorded, the organs being of nearly normal size and contour, with their ureters correspondingly shortened and their vascularization of abnormal origin. Occasionally such kidneys are single, the opposite organ being absent or atrophic. Where misplacement and fusion types are combined anomalies of the ureters and vessels are the rule. The usual locations of the misplaced kidney, named in the order of their frequency, are at the bifurcation of the aorta, at the sacral promontory, over the sacro-iliac joint, in the iliac fossa or in the hollow of the sacrum. The misplaced or malformed and fusion type of kidney shows a great diversity of anomalies of ureters and vascularization as well. If the kidney becomes fixed before the midlumbar level is reached, where rotation normally occurs, the hilum of the single kidney, and usually each hilum of the fusion types, will remain in the ventral position. The arterial supply usually comes off slightly anterior to the location of the misplaced organ, most frequently close to the aortic bifurcation, or from the common or internal iliacs, and these anomalies serve to distinguish the congenital from the acquired form of misplacement, for the latter, even when fixed by adhesions, show vessels arising from the normal sites on the aorta and vena cava. The suprarenal gland does not participate in congenital misplacement.

Diagnosis.—Congenital misplacement of the kidney is found about once in 1000 bodies. When the organ is situated above the pelvic brim and is otherwise normal, it usually escapes detection during life, as few, if any, symptoms are to be expected. A diagnosis of a non-diseased misplaced kidney above the pelvic brim is rarely made. Even when discovered in the course of abdominal palpation the mass felt is generally taken to be some other form of tumor. When encountered during operations for other conditions these anomalous organs have been removed without knowledge of their real nature and in a few cases, in which they were solitary organs, with fatal results.

A situation below the pelvic brim increases the likelihood of symptoms from the dystopic organs. While the congenital misplacement is more common in men, women more frequently exhibit symptoms, among which may be mentioned disturbances of menstruation, obstipation, interference with pregnancy and parturition, and further subjective symptoms, some even of the psychic nature that are commonly associated with pelvic tumors. In fact, in pelvic examinations, misplaced kidneys have frequently been diagnosed as tumors of the organs of generation.

The anomaly of position, accompanied as it usually is with defects in morphology, renders these organs prone to the development of hydronephrosis, of both the congenital and acquired type, as well as

to the acquirement of infection and stone. Such complications, when the hematuria, pyuria, or vesical spasm that often accompanies them are investigated efficiently, are likely to lead to the discovery of the misplacement, particularly when radiography with opaque catheters and pyelography are employed. Neoplasms of these kidneys are relatively frequent.

Treatment.—The healthy organ causing symptoms merely because of its position may in some instances be freed and then fixed in a more favorable site without interference by tension with its blood supply or ureter. More often, however, removal is indicated and this necessitates absolute proof of the presence of another functionally competent and healthy organ, for so frequently the misplaced kidney is "solitary." Nephrectomy has been performed by the sacral and vaginal routes and transperitoneally through a lateral incision, as well as by laparotomy, which is, however, the preferable method in these cases.

Anomalies of the Blood Supply.—The frequency with which variations in the vascular supply of the kidney are encountered in organs whose form is normal, as well as in cases showing the foregoing anomalies of form, is of much surgical importance. Additional arteries are the most common anomaly. Such accessory vessels usually enter the organ at the poles, those at the upper pole being most frequent. In organs showing even the slightest evidence of persistent fetal lobulation, such vessels are the rule, and in some of the fusion forms of the kidney, such additional vessels are most numerous. The vessels usually come off directly from the aortic trunk, but branches from the suprarenal, hepatic, lumbar, colic, the iliacs, and sacral arteries are found. The main renal arteries may come off by a single trunk from the anterior part of the aorta, or a renal artery may arise from the opposite side of the aorta. The fact that the kidney is not vascularized until it reaches its permanent resting-place would account for the fact that in cases of congenital misplacement of the kidney its main blood supply is derived from the large arteries of the immediate region in which it lies. In operations upon the kidney, especially in nephrectomy, the possible presence of accessory arteries and anomalous origins of the vessels must be borne in mind.

Anomalies of the Ureters.—Kidneys showing no other deviation from the normal may exhibit many anomalies of their pelves and ureters. It will be remembered that the renal buds are given off into the metanephric mesenchyme from the dorsal aspect of the Wolffian ducts close to the points of entrance of the latter into the cloaca, and that the dilated end or ampulla of each bud then divides into an anterior and a posterior pole, which point of division forms the site of the primary renal pelvis. Among the possible variations in this general process are cases in which additional buds are given off from the duct and so lead to a complete reduplication of pelvis and ureter with separate points of entrance into the bladder, or the division of

the original bud may occur early or be uneven, so that the adult ureter is reduplicated for variable portions of its course, usually the upper two-thirds, the two elements being joined below and entering the bladder by a single duct in the normal position. In the case of complete double ureter the one draining the upper pole lies behind the lower and crosses it to enter the bladder cavity at a lower point. These anomalous ureteral openings are usually found in the general

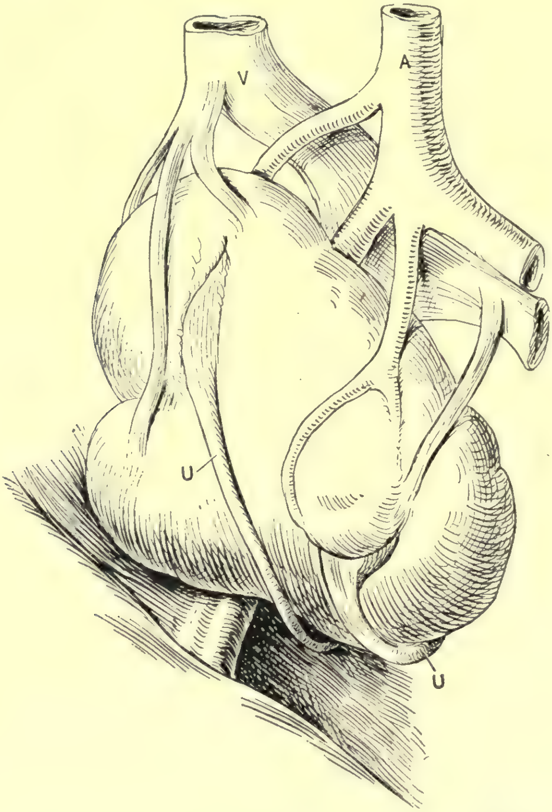

FIG. 161.—Solitary fusion kidney located at pelvic brim. Anomalous blood supply. Two ureters.

region of the trigone, but may be present in any part of the bladder wall, the prostatic urethra, vas deferens, and seminal vesicles in the male, or the urethra, vagina, or rectum in the female. With these extravesical and urethral orifices, except in some cases opening into the prostatic urethra, there is, of course, dribbling of urine from infancy, occurring in conjunction with apparently normal evacuations of the bladder. Surgical measures for the vesical implantation of such aberrant ureters are, of course, indicated.

When the urethral orifices are constricted or impervious there is a resultant dilatation of the ureter throughout its length, or in its intra-

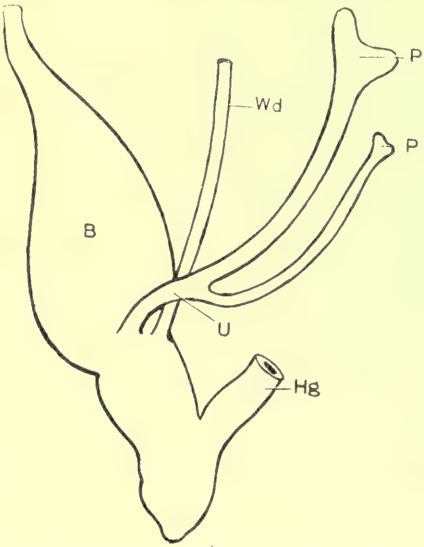

FIG. 162.—Showing double renal pelves and ureters with a single opening into the bladder: *B*, bladder; *P*, renal pelvis; *U*, ureter; *Wd*, Wolffian duct; *Hg*, hindgut.

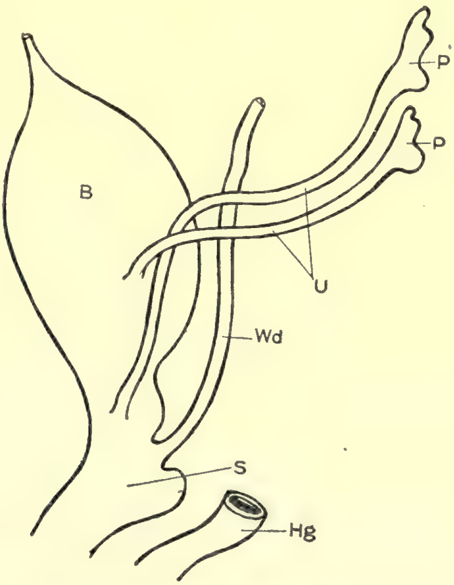

FIG. 163.—Showing double renal pelves and ureters, with separate openings into the bladder: *B*, bladdeı; *P*, renal pelvis; *U*, ureter; *S*, urogenital sinus; *Hg*, hindgut.

muscular portion alone, followed by hydronephrosis, cystic degeneration, or atrophy of that segment of the kidney from which the ureter comes off. Similarly, infection may enter one of the ureters and lead to an inflammatory process in the kidney, limited to that portion drained by the affected ureter.

A ureter opening into a seminal vesicle or the vas or ejaculatory duct may lead to a cystic dilatation of those structures, which is discoverable as a bulging forward of the posterior bladder wall. Cystic tumors projecting into the bladder in the region of the trigone, occasionally growing to a large size, and causing symptoms from pressure, may start as a dilatation of the intramuscular portion of the ureter

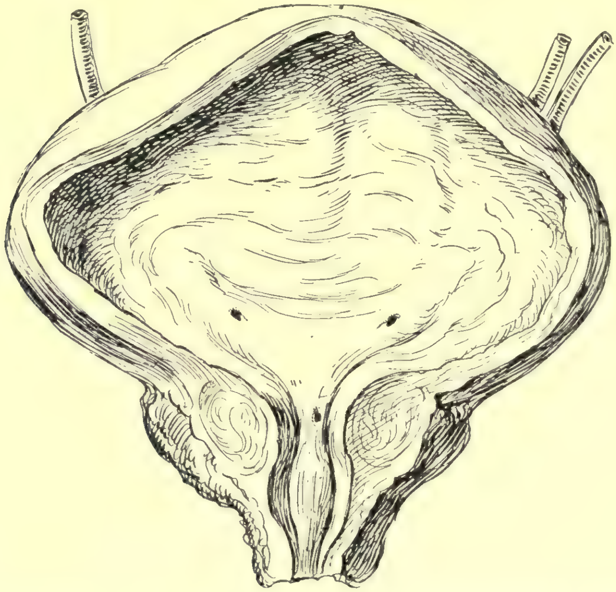

FIG. 164.—Interior view of bladder, showing anomalous openings of extraureter into prostatic urethra.

as the result of stenosis of its orifice. The presence alone of such tumors should suggest ureteral anomalies. Ureteral orifices of too generous size or with imperfect sphincteric musculature may lead to an intravesical prolapse of the ureter, occasionally of considerable degree.

Congenital valve-like constrictions and even occlusions of the ureter are found chiefly at its junction with the renal pelvis at the pelvic brim and in the intramuscular portion of the bladder wall. Unless of sufficient degree to cause marked dilatation of the ureter or renal pelvis, such anomalies are not likely to be discovered. Cystoscopic examination and radiographs of the catheterized ureters give the final word in the determination of these ureteral anomalies. In

general, it may be said, as was the case in malformations of the kidney itself, that these congenital lesions of the ureter predispose to the incidence of infection, particularly when the condition of hydronephrosis is present.

HYDRONEPHROSIS.

When the outflow of urine from the renal pelvis is partially impeded, or a slowly developing complete obstruction occurs, so that the pelvis and calyces are dilated by the retained aseptic urine, the condition is spoken of as hydronephrosis, the "*sackniere*" of Küster; nephrectasis of Morris. The term uronephrosis also is used synonymously, and perhaps more correctly. When infection occurs in conjunction with the urinary retention, the term pyonephrosis, or infected hydronephrosis, is used to designate the condition. The former term is applied to the more severe forms of infection occurring in the course of a hydronephrosis and also to the distention of pelvis and kidney produced by pus in a process that was primarily and essentially suppurative. Since the retained urine accumulates under pressure the distention of pelvis and calyces is followed by back pressure in the renal tubules and a consequent atrophy, first of the tubular structures, then of the pyramids, and of the cortex, so that in extreme cases the organ exists as a thin-walled, somewhat lobulated, fibrous sac filled with urine of altered character. It must be said, however, that for the development of such an extreme condition the survival of some renal elements, glomeruli, and tubules, in the thinned-out parenchyma until the latest stages, is essential, and that the obstruction must have been only partial, or at least of an intermittent nature. A complete obstruction occurring suddenly and remaining permanently is seldom followed by the development of hydronephrosis. While some distention of the pelvis and calyces occurs it is usually of mild degree, and the rapidly increasing back pressure results in a sudden cessation of renal function or rapid inhibition of function and atrophy of the kidney. Hydronephrosis is more common in the female than in the male, and on the right side than on the left.

Hydronephrosis may be the result of *congenital* or of *acquired* conditions that obstruct the outflow of urine from the kidney. Such obstructions may be located at practically any point along the urinary passages from renal pelvis to urethral meatus and may be the result of developmental defects or of pathological processes and purely mechanical factors located either within or without the urinary tract.

A hydronephrosis that owes its origin to embryological abnormalities may be present before birth in a rather advanced degree of development or may not manifest itself until later in life. A reference to the section on anomalies will indicate the multiplicity of conditions favorable for the development of this lesion. Unilateral hydronephrosis is in the great majority of cases of the congenital type. Faulty development of the lumen of the ureter, with constrictions at practi-

cally any portion of its course, particularly stenosis at or near the vesical orifice, is one of the frequent causes. This latter condition is especially frequent when double ureter is present, or the ureteral orifice is located out of the region of the trigone, and in exstrophy of the bladder. Anomalies of position of the kidney furnish their quota of cases, for the erratic course of the ureters renders them subject to extra-urinary constrictions and various torsions of a mechanical origin. Within the ureters themselves valve-like plications and constrictions of their lining membrane and other persistent remains of fetal morphology may account for the obstruction. Anomalous vessels may in pursuing their course press upon the ureter and cause it to kink sufficiently to impede the flow of urine. Many cases are

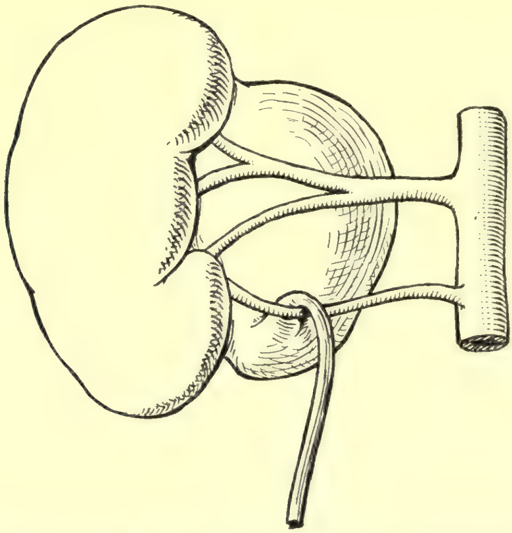

Fig. 165.—Hydronephrosis due to kinking of ureter by aberrant branch of renal artery.

probably erroneously ascribed to this cause, the apparent constriction of the ureter having appeared as the result of the dilatation, which was really due to a condition located elsewhere. This mistake is frequently made when the hydronephrosis has been due to abnormal mobility of the kidney, either of the congenital or of the acquired type, in which case the aberrant vessels are then merely aggravating causes. Finally, certain anomalies of continuity of the ureteral lumen at the junction of the pelvis and ureter are the cause of many of the cases of retention of urine within the kidney. Ureters arising from the upper portion of the pelvis, or at an unusual angle from it belong to this class. In such cases even moderate distention of the pelvis may cause acute angulation and constriction of the lumen by pseudovalve action.

Congenital obstruction arising from conditions within the bladder is rare, and is usually attributable to some interference with the outflow at the vesical orifice of the urethra. Obstruction at, or distal to, this point leads to bilateral hydronephrosis. Imperforate or stenosed urethra, valve-like structures and diverticulæ of its lining membrane and the much-constricted meatus often found in hypospadiacs comprise the more common forms of congenital urethral obstruction. To these may be added constriction of the preputial orifice. Owing to the bilateral damage the kidney's life is threatened and early operative relief is essential.

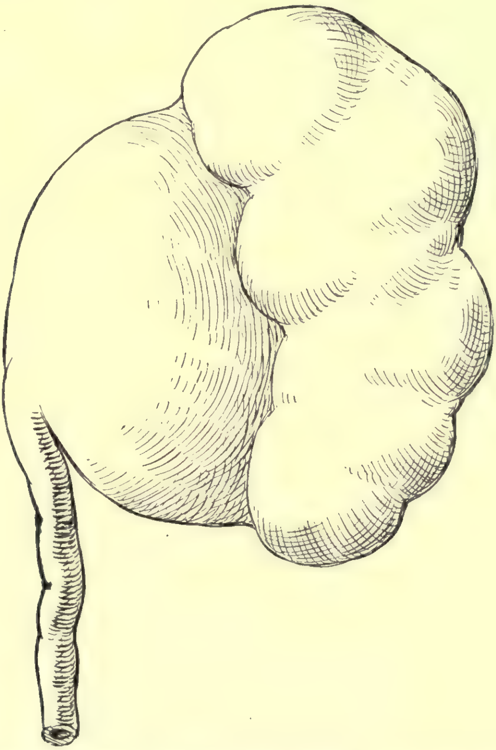

FIG. 166.—Hydronephrosis of well-advanced degree. Note high implantation of ureter on sac and the lobulated appearance of the kidney.

Congenital cystic dilatation of the lower, intramuscular, end of the ureter may, by angulating the ureter, lead to uronephrosis, when the constricted ureteral orifice had not done so. Rarely, a hydronephrosis is the result of obstruction of the pelvic outflow by calculus formation occurring before birth, while relatively often, as noted above, the congenital lesion leads to stone as a later complication.

Acquired Hydronephrosis.—Acquired hydronephrosis may arise from causes situated in the urinary tract itself, or may occur as the

result of compression of some portion of the tract by lesions of neighboring structures. When the obstruction is below the vesical orifices the condition necessarily is bilateral, although marked differences in the degree of distention on the two sides may sometimes be found. In this category of etiological factors belong strictures and other obstructions of the urethra, enlarged prostate, vesical calculus, seminal vesiculitis, and occasionally the hypertrophy of the bladder due to excessive functional activity.

Unilateral hydronephrosis is in the great majority of cases due to some factor of embryonic origin. Occasionally when the condition has apparently had its inception in adult life examination will show that the underlying cause was really of a congenital nature. Such a state of affairs might occur from a congenital stenosis of a ureter with a lumen just sufficiently large to permit the passage of urine under average conditions, but which causes distention of pelvis and kidney in the active diuresis following drinking bouts.

Among the causes of acquired unilateral, or even bilateral, hydronephrosis arising within the tract may be mentioned calculi and foreign bodies within the lumen of the ureter, strictures following injury of its wall or mucosa from ulceration, trauma and inflammatory processes, and obstruction due to neoplasms and infectious granulomata of the ureter. Tumors of the kidney itself involving the pelvis may block its outlet.

One of the most common causes arising from without the tract is abnormally movable kidney. Inflammatory processes about the ureter and renal pelvis may by the formation of bands of adhesions and by the contraction of scar tissue lead to compression. Abdominal and pelvic tumors, uterine displacements, and fecal impactions all figure as common causative factors of this condition in women.

It must be remembered in considering the causes of acquired hydronephrosis that the obstruction must be partial or intermittent, or if finally complete, must have been of slow development.

Calculi obstructing the ureter usually lead to renal atrophy or pyonephrosis, but when situated at the outlet of the pelvis or in the vesical end of the ureter may lead to dilatation, or by their presence cause ulceration and subsequent stricture. The ball-valve action of the rounded ureteral stone or the cone-shaped pelvic stone produces the intermittent type of obstruction that eventually leads to a well-marked permanent dilatation.

Traumatic injury of the ureter, followed later by hydronephrosis, may occur in the course of abdominal or pelvic operations. Complete and permanent obliteration of the lumen by ligature or misapplied clamp and a resultant renal atrophy is, however, more common. Injury of the ureter and stricture formation due to unskilful catheterization is said to have occurred. Rupture of the ureter may follow a blow on the loin, in which case the extravasation of blood and urine that occurs about the ureter or in the perirenal tissue within a few days,

or almost immediately, may simulate a hydronephrosis, but the true condition occurs much later and as the result of compression by the contracting scar tissue. In some instances the dilatation of the kidney was present before the receipt of the injury to which the condition is ascribed. Neoplasms, granulomata, and the various inflammatory processes other than those caused by stone are rarely primary in the ureter. Pyelitis of various types, on the other hand, is more frequently met with, and involvement of the ureteropelvic junction with subsequent constriction often ensues.

Abnormal mobility of the kidney may be a congenital or an acquired condition. In the course of the migrations of the organ, the ureter, especially when its upper portion is fixed by inflammatory adhesions, or when anomalous vessels are present, is likely to become kinked, and retention and dilatation be the result. This produces the intermittent type of hydronephrosis, for when the kidney resumes a normal position or is replaced, the ureter straightens and the retained urine escapes. Urinary retention with dilatation of the pelvis and kidney from other causes may lead to abnormal mobility of the kidney as the result of the increased weight of the organ, so that errors in determining the true etiological factor of the hydronephrosis may ensue. Next to pelvic tumors, movable kidney is the most common cause of hydronephrosis in women. Unless, however, the intermittent obstruction is frequent and persistent dilatation does not occur, even in cases where definite "crises" are present from time to time.

Pathology.—It has been said that, despite apparent exceptions, an immediate and complete closure of the ureter does not cause true hydronephrosis. There is, however, in most cases an undeniable dilatation of the ureter and of the renal pelvis, but a cessation of renal activity quickly supervenes. A portion of the retained urine is resorbed and the kidney passes into a state of atrophy and sclerosis. The condition has been spoken of as a "closed uronephrosis" by the French. The same term is at times applied to a true hydronephrosis in which the obstruction, of gradual onset, has finally become complete and permanent. In such cases total atrophy of renal parenchyma occurs only after a considerable length of time, but the retained urine is greatly altered in character. Urea, uric acid, and other constituents may be greatly diminished, or even lacking, the specific gravity low, color and odor slight. There may be hemorrhages into the sac, staining the fluid with blood pigments (hematonephrosis), or calculus formation may result in irritation, a low-grade inflammation and moderate amounts of pus. In some cases the contents are of a colloid nature. The liability of the hydronephritic kidney to infection and the condition of pyonephrosis has been spoken of before. The "open nephrosis" of long duration leads to the development of dilatation of the greatest size. The average capacity of the renal pelvis is about 7.5 c.c. with a normal range of from 1 to 20 c.c., while hydronephritic cysts containing enormous amounts of fluid (36,000 c.c.) have been reported.

Following the partial obstruction of the ureter, the pelvis of the kidney becomes dilated. The process is a progressive one and the calyces then take part in the distention, become globular in form, and the kidney substance is thinned out over them (Fig. 168). The papillæ are flattened and as the thickness of the parenchyma is diminished the surface of the kidney often appears lobulated, corresponding to the areas of dilated calyces. In some cases the pelvic distention so far outstrips that of the kidney that the latter, often little larger than

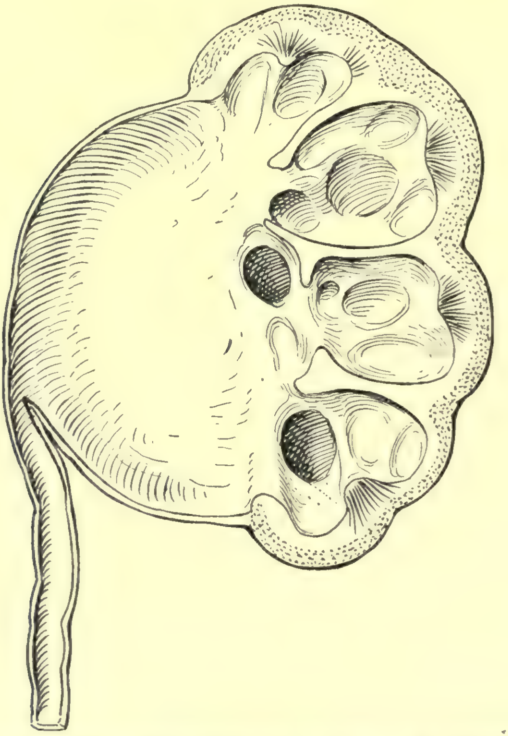

Fig. 167.—Section through organ pictured in Fig. 166. Note pseudovalve at the ureteropelvic junction, dilatation of calyces, and thinning out of renal cortex.

normal, appears to cling to the side of the enlarged cyst-like pelvis. Other cases show a more uniform process with dilatation of pelvis and kidney and gradual atrophy of the interlobular septa and cortex so that the final result is a thin-walled unilocular cyst. Except in the cases recognizable as the extreme degree of hydronephrosis some attenuated parenchyma may be found in the cyst wall. Occasionally it is found that the kidney alone has undergone dilatation. In such instances the pelvis may be entirely surrounded by the distended kidney, and is often found fibrosed and contracted about a stone.

When the obstruction is situated below the junction of the ureter and pelvis, the portion of the ureter above the obstruction, as a matter of course, takes part in the dilatation and may attain the diameter of the intestine. More often, however, it is about the thickness of the finger. A hydronephrosis of but one portion of the kidney may occur in cases of anomalous division of the pelvis. The fusion type of single kidney also may present this condition.

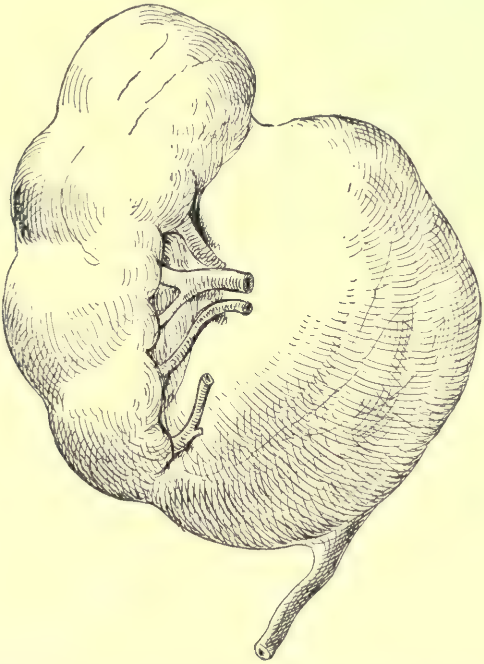

FIG. 168.—Hydronephrosis principally affecting the pelvis.

Histology.—As the pressure within the pelvis and calyces rises, the renal tubules participate in the dilatation. Their epithelium becomes flattened and may exfoliate. These changes are accompanied by a fibrosis and round-cell infiltration of the interstitial tissue, while the pressure on the vessels leads often to slight interstitial hemorrhages. Atrophy of the tubules quickly supervenes. The distention of the tubules is communicated to Bowman's capsules, where the pressure of the fluid on the glomeruli leads to their fibrosis and obliteration. The dilatation of the calyces causes pressure upon the large drainage veins of the kidney at an early stage, so that a chronic passive congestion results. This condition in itself leads to sclerotic changes in the arteries and the interstitial tissues. In spite of the combination of these destructive factors it is only in the most extreme cases that

islands of healthy appearing tubular and glomerular structures cannot be found on careful examination.

Physiology.—The histological processes noted above are accompanied by physiological disturbances which are of course incompatible with adequate renal function, and, if the condition is bilateral, uremic symptoms become manifest. The onset and course of such uremia may be of a protracted nature. Even though the condition be unilateral, the compensatory hypertrophy and increased physiological activity of the opposite kidney may at times be nullified by reflex inhibition of its functional activity. Not infrequently the increased work that it is called upon to perform, when added to the systemic disturbances produced by the diseased organ, leads eventually to an interstitial fibrosis which so reduces its capacity for elimination that uremia supervenes.

Symptoms.—For the purpose of clinical differentiation hydronephrosis may be classified as *latent*, *intermittent* and *persistent*. In the early stages the condition may exist and slowly progress without giving symptoms that would direct attention to a renal disorder and without producing a tumor of sufficient size to make it readily discoverable by palpation. In such cases death from uremia may occur without the true cause being ascertainable except at autopsy. Where a palpable renal tumor is not present, the condition is spoken of as *latent*. The early stages may, however, be characterized by continuous pain of a dull aching type located usually in the loin just below the costomuscular angle or by intermittent pain of a colicky nature similarly located. Attacks of polyuria are another frequent symptom of this stage.

The symptoms, pain and polyuria, are usually marked in hydronephrosis of the second or *intermittent* type, and a renal tumor may be palpated at the time of the attacks at least. If such a tumor has been known to exist, it is often found to have become enlarged with the sudden onset of the pain and tenderness over the kidney and at the "kidney points." In some cases pain of the typical renal colic variety is complained of. Oliguria usually characterizes the stage of pain which usually also ceases suddenly, either spontaneously, or as the result of some postural treatment, manipulation of the tumor, or on merely taking to bed. The consequent relief of the obstruction is followed during the next twenty-four to forty-eight hours by the passage of large quantities of urine, occasionally containing blood in cases of the Dietl's crises type or where stone or papilloma has caused the obstruction. After the polyuria the tumor may then be found to have diminished in size. This type of hydronephrosis is particularly frequent in cases where the condition is due to movable kidney, or is the result of some diuretic stimulation in cases due to partial stenosis of a ureter. During the acute attack prostration may be pronounced. Fever is practically always absent. The largest examples of hydronephrotic sacs belong to the intermittent type.

In the absence of complications the *persistent* or constant type of hydronephrosis shows symptoms that, except for the presence of a tumor, are slight. Pain of a dull aching nature is the usual complaint. The urine passed is normal in amount and quality, providing the opposite kidney is healthy. Since there is no complete or partial emptying of the sac as in the foregoing type, many of these cases eventually become what has been spoken of before as a "closed" hydronephrosis and seldom reach a large size.

Diagnosis.—From the therapeutic stand-point it is important that the diagnosis of a hydronephrosis be made before the development of a palpable tumor. The symptoms exclusive of tumor should lead to a systematic examination according to the methods afforded by the modern additions to our diagnostic armamentarium.

It must be shown that there is at least a definite dilatation of the renal pelvis. In addition, also, the location and nature of the obstruction should be sought for. Furthermore, the state of the opposite kidney as regards its anatomical and functional condition must be known before surgical measures are undertaken.

In the more advanced cases it is important to learn not only the extent of the dilatation of the affected kidney, but also, from a prognostic point of view, to determine its functional capacity. The examination of the bladder urine shows nothing of diagnostic value in the case of an uncomplicated unilateral lesion when it is of the closed variety and the opposite kidney is normal. In the intermittent cases, however, during the stage of polyuria the urine is of low specific gravity and deficient in urea and salts and in rare cases may contain blood or its pigment. Infection, stone, neoplasms, etc., of course may add their quota of pathological elements.

The data derived from a cystoscopic examination in conjunction with the detection of a cystic tumor in the renal region may be sufficient to determine a positive diagnosis. If no urine is found to be flowing from the ureteral orifice on that side and there is active secretion from the other side the presumption of hydronephrosis is obvious. The ureteral orifice shows no morphological change if the obstruction is above the bladder wall. When the examination is made during the stage of polyuria, the contraction of the ureteral orifice on the side of the lesion is more frequent than on the sound side. In the stage of oliguria the contractions are fewer and slower on the affected side. In the older "open" cases with a constant tumor the urine flow may be slow but continuous, and in some cases may be accelerated by pressure upon the tumor. When the fibrous sac stage is reached the kidney pelvis has lost its musculature and the renal parenchyma is destroyed, so that there is no longer any flow of urine, and the ureteral orifice remains quiet. By having the patient drink a considerable quantity of water and by the injection of indigo-carmine or methylene blue these examinations will be greatly aided and a relative estimation of the functional capacity of the two sides may be formed from the depth of the color of their secretion.

The early stages of hydronephrosis may not be recognizable from cystoscopic examination alone, and recourse must be had to ureteral catheterization. This procedure is not only necessary in some cases for diagnosis but also should be done in all cases for the absolute determination of the functional capacity of the sound organ as well as the diseased one. The technic of this procedure is treated elsewhere.

The capacity of the average renal pelvis is stated to be about 7 c.c. with normal variations of from 1 to 20 c.c., and according to Brödel the capacities of the two sides are equal. As a rule the capacity of 30 c.c. is considered to constitute a hydronephrosis. A capacity of 150 c.c. or over is regarded as indicating considerable loss of kidney substance. By emptying and refilling the pelves with warm boric acid solution through the ureteral catheters to the point when pain begins (of the sort often complained of symptomatically) the relative capacities may be ascertained. With the catheters in place the urines from the two sides may be collected and examined separately, for urea output especially, and by the use of the phenolsulphonephthalein or indigo-carmine method, the respective functional capacities may be learned. In early cases, with little dilatation, the functional capacity is little affected. Old cases with large kidneys may show no elimination of the dyes.

While the ordinary *x*-ray picture may in some instances suggest or confirm a diagnosis of hydronephrosis, when the condition is due to stone, the satisfactory application of the *x*-ray in the diagnosis of this condition has been made possible by the injection of metallic solutions (collargol, thorium, etc.), opaque to the rays, into the renal pelvis, so that a picture of the shadow demonstrating the outline of the pelvis may be obtained. The shape, size, and position of the shadow confirm or deny the diagnosis. It is well to have a similar picture of the sound size for comparison. The method is called pyelography and has done much to advance diagnostic efficiency. Used in conjunction with opaque ureteral catheters, the cause of the obstruction may in some instances become evident.

Differential diagnosis is concerned chiefly with the physical examination, when the palpable tumor must be distinguished from enlargements of the gall-bladder, cysts of the pancreas, mesentery, ovary, and encysted ascites, or from neoplasms of the liver (hydatid cysts), spleen, and of the kidney itself. Among the renal enlargements other than hydronephrosis may be mentioned polycystic kidney, hydatid cysts, pyonephrosis, and those due to tuberculosis, calculus, and the strangulation in Dietl's crises. The possibility of mistaking the collections of urine or blood from traumatic injury of the kidney or ureter for a hydronephrosis has been mentioned already. A perirenal abscess may lead to a similar error. The shape, size, and consistency (fluctuation) of the tumor, its relation to the anterior belly wall, and particularly its relation to the colonic percussion area, must be taken into consideration.

When renal colic is a predominating symptom the various other causes of this symptom, such as stone, blood clots, tuberculosis, etc., must be eliminated. Hematuria is a rather rare accompaniment of hydronephrosis and its cause, even in this connection, is not usually due to the dilatation itself. In the cases of the latent type, especially in the bilateral cases due to vesical or urethral obstruction, the actual condition may go unrecognized because of a diagnosis of chronic nephritis of the interstitial type based on urinary examination alone.

Prognosis.—Hydronephrosis usually runs a protracted course. As a rule, unless infection occurs or uremic symptoms become manifest, the individual exhibits general good health and the occasional attacks of pain, the periods of oliguria, followed by polyuria or hematuria may not lead to the need for operative relief. The end usually comes as the result of a uremia of gradual onset, but complete suppression, due to some added burden, such as infection, may lead to sudden death. Cases of apparently spontaneous cure have been recorded.

Where the hydronephrosis is due to an obstruction in the urethra or bladder the prognosis is more grave, for in addition to the usually bilateral involvement of the kidneys, infection is more likely to occur. If the condition is due to excessive mobility of the kidney, strangulation of the hydronephrotic organ may occur through torsion of its vessels. Early surgical relief of this condition is essential. Rupture of the sac into the peritoneal cavity has seldom been recorded. Unless such a complication was followed by quick surgical intervention peritonitis with a fatal outcome would result.

The early diagnosis of a unilateral hydronephrosis when followed by removal of the cause usually results in a cure. Later diagnosis does not extend so favorable a prognosis, for not only has the affected kidney undergone greater pathological changes, but the second organ likewise has been subjected to damaging influences. In reality the ultimate outcome depends largely on the state of the unaffected organ from the stand-point of functional capacity. In bilateral hydronephrosis the prognosis is always more grave, for even if the cause can be removed the damage already inflicted upon the kidneys plus the usual likelihood of infection lessens the probability of actual cure.

Treatment.—Owing to the progressive nature of the disease, the liability to infection, and the possible insidious onset of uremia in the latent form, or the inevitable uremia in the bilateral type, immediate active treatment should be instituted in hydronephrosis. With few exceptions operation offers the only adequate means of effecting complete and permanent cure. In the early cases it means the saving of a functionally competent organ and in the older cases pyonephrosis or uremia may be warded off. The bilateral cases due to urethral or vesical obstruction in particular demand immediate attention. The relief of the retention in the kidney is the first consideration, whether this be accomplished through nephrotomy as an emergency measure or by the more advisable method of removing the cause of the obstruc-

tion, or otherwise providing for free outflow through the normal channels by catheterizing and draining the sac.

Although a kidney once injured by distention never returns to a completely normal state, even one that does not possess complete functional capacity deserves every effort toward its preservation, and except in cases where the usual examinations and functional tests show a hopeless destruction of secreting substance or in the presence of infection or repeated crises, surgical measures dealing with the kidney itself should be of a conservative nature. In the latter cases nephrectomy is the operation of choice, both for the relief of the pain and discomfort or the threatened dangers incidental to the type of lesion, and for the saving of life in the infected cases.

In the acute attacks of the intermittent type certain measures of a palliative nature may be instituted. Rest in bed, postural and local manipulative measures (massage), and the use of morphin may be mentioned as being of value, particularly in the cases due to movable kidney. In some cases relief of the distention by catheterization of the renal pelvis and drainage of the sac is feasible. Nephrotomy or aspiration of the sac through a lumbar incision is preferable to the ordinary "tapping" through the flank. In some cases of the movable kidney variety, attacks may be prevented or relieved by the use of properly applied bandages.

Complete removal of the entire sac of a hopelessly hydronephrotic kidney is preferable to nephrotomy and the resultant production of a persistent urinary fistula, unless it has been impossible to ascertain absolutely the condition of the opposite kidney. The attempts to obliterate such sacs by the injection of iodine or other irritants are mentioned only to be condemned. In some infected cases it is at times advisable to open and drain the sac as a preliminary to its extirpation. The method of choice is the extraperitoneal operation through the lumbar incision.

The operative procedures called for when the affected kidney is shown to possess sufficient functional capacity to warrant its conservation may be classified as those directed toward the removal of the cause of the obstruction and those aimed toward the reduction of the size of the sac. The factor causing the obstruction suggests the nature of the operation required. In urethral, vesical, or pelvic obstruction the removal of the cause, whether by urethrotomy, prostatectomy, or extirpation of uterine and ovarian tumors and the products of pelvic inflammatory disease, falls in the line of conventional surgical measures. When the obstruction lies in the ureter or at the uteropelvic junction the measures for relief are of a more specialized nature. Strictures or stenoses of the ureteral orifices or their occlusion by stone or neoplasm may be treated *via* the cystoscope by dilatation, cutting, or the use of radium or electricity. Some cases of stricture along the course of the ureter may be permanently relieved by dilatation, but in most instances plastic work on the ureter itself through the lumbar-inguinal-trans-

peritoneal route is called for. This may consist of simple incision for the removal of a stone with suture of the incision (not forgetting the tendency to subsequent stricture) or excision of the stenosed area and restoration of the channel by end-to-end lateral, or end-to-end anastomosis, or by the invagination of the upper end into the lower. In some instances where the lesion lies close to the bladder the implantation of the upper end of the ureter into another portion of the bladder is called for.

If the obstruction lies near the renal end of the ureter, operative procedures are carried on through the lumbar incision after exposing the kidney, the sac, and the upper portion of the ureter from behind. Simple stricture in this region may at times be amenable to cure by catheterization and dilatation from above through an incision into the renal pelvis; however, the greater number require operations of a plastic nature on the ureteropelvic junction. These may be carried out either from inside or outside of the pelvis, and consist of the usual longitudinal incision of the constricted area followed by transverse suturing so as to increase the diameter of the lumen as in pyloroplasty, or of incision or excision of the lip-like pseudovalve formed by the high implantation of the ureter on large sacs. Occasionally it is advisable to implant the ureter into the most dependent portion of the sac or to do a side-to-side anastomosis at such a point. The orthopedic resection or "capitonnage" of Albarran consists in the excision of both that portion of the kidney and of the sac which lies below the level of the outlet and the suturing together of the opening thus formed.

In a large group of cases, abnormal mobility of the kidney is the etiological factor or a contributing cause of the obstruction, or may be merely the results of the dilatation and increased weight of the organ when it may serve to increase the obstruction or produce added symptoms. The suspension and anchoring of such a kidney in a favorable position may in some instances be sufficient to cure the condition, particularly in the early cases. It should be done also when there is excessive mobility in cases in which the obstruction was due to some other cause after the obstruction has been relieved. In the presence of unusually large sacs the suspension is of little use unless the sac be obliterated or reduced in some manner.

Obstructions caused by anomalous vessels, fascial bands, or inflammatory adhesions are to be relieved by cutting the bands or adhesions, and occasionally, when the vessel is a branch supplying only a small area of kidney, it may be cut between ligatures and the ureter freed. It must be remembered, however, that such interference with the blood supply leads to degeneration or necrosis of the kidney substance supplied by it. In general, it is preferable to cut the ureter and implant the inferior end into another portion of the sac or to do a lateral anastomosis between ureter and sac below the point of obstruction rather than divide the blood supply. When the vessel is a large one cutting it is of course out of the question.

When plastic work has been done on the ureter or at the ureteropelvic junction a catheter should be left in place for several days to ensure free outflow for the urine and to prevent hydrostatic pressure on the suture line while healing is taking place.

After removal of the cause of obstruction and in some cases where in addition the size of the hydronephrosis predisposes to the retention of urine, it is desirable to reduce the size of the sac or to take up any bagging below the level of the outflow of the renal pelvis. The orthopedic resection already has been mentioned. Portions of the dilated pelvis alone may be excised and the opening sutured or various methods of plication and infolding of the redundant sac wall by sutures may be practised. These various plastic operations may be called for in cases of double pelvis in which only a portion of the kidney is affected and in solitary kidney of the "horseshoe" or fusion type.

Emphasis must be placed again on the importance of ascertaining the functional capacity not only of the supposedly sound kidney, but also of the affected one, before undertaking any of these operations for the conservation of the organ. It is manifestly a waste of time and an unjustifiable inroad upon the vitality of the patient to undertake an elaborate plastic operation on a kidney that is useless from a functional stand-point, when the symptoms and discomforts it may be causing can be more readily and safely relieved by the relatively simple operation of extirpation. Improvement in functional power may be looked for when these operations are performed in the earlier stages of hydronephrosis, but as time passes the injury and destruction of the secreting structures increase and the favorable outcome is progressively less frequent. It is incorrect to speak of regeneration of the kidney, for any improvement obtained is due merely to the increased functional activity of the structures that have not been hopelessly injured. Data of much value in a prognostic sense, and as a guide to choice of operation, could be accumulated by recording accurately the functional results obtained for long periods after these operations. The necessary examinations could be carried out when the periodic catheterizations that are so necessary to offset the tendency to postoperative stricture are done.

MOVABLE KIDNEY.

Although under normal conditions the kidney has a range of motion in an up-and-down direction, averaging from one to two inches, the term movable kidney has come, as the result of usage and convenience, to have an almost exclusively pathological significance. As indicating a usually more severe degree of mobility, the term floating kidney has been in general use, but anatomically speaking, it should be reserved for those rare cases in which the organ, as a congenital anomaly, has a complete peritoneal investment and mesonephron, and is in the usual sense an intra-abdominal organ, enjoying a wide range of mobility.

Nephroptosis is a more correctly descriptive name for the condition

in which the kidney is found to be abnormally movable. Glénard, who coined the term, described four degrees of pathological mobility: (1) when the lower pole is palpable on inspiration; (2) when the greater part of the organ is palpable on inspiration; (3) when the whole organ is palpable on inspiration; (4) when the whole organ is palpable without the aid of the inspiratory descent of the diaphragm.

Mobility of an abnormal degree is more common in women than in men (ten to one), and on the right side than on the left (fifteen times), but both kidneys may be affected. Its period of greatest incidence is from the twenty-fifth to the fiftieth year, but cases have been found in early infancy and have developed in old age. The condition is usually an acquired one, but it may be congenital, as in the true floating kidney, and the frequency of its occurrence in certain well-recognized types of body conformation point to a congenital predisposition. Movable kidney of marked degree may exist without giving rise to any symptoms whatsoever, or it may lead directly to hopeless invalidism. Abnormal mobility is found to be present in some degree in about 22 per cent. of women, while only about 2 per cent. of men show it.

Nephroptosis is so frequently found in association with splanchnoptosis that some writers have believed that it had a common etiological factor with the latter condition, and certain French authors consider it one of the stigmata of degeneracy.

Anatomy.—Reference to the section on the anatomical relations will show that the kidneys are held in position in the paravertebral fossæ or renal niches chiefly by their fatty capsules and by intra-abdominal pressure, which is somewhat above that of the atmospheric pressure. Under normal conditions the peritoneal folds, fascial bands and vascular pedicles play a very small part in the support of their weight. The delicate connective-tissue fibrillæ loosely connecting the perirenal fascial layers with the renal capsule proper are practically incapable of influencing the position of the organs when the abundant interstitial adipose is absent. The attachments between the kidney and adrenal gland which are well marked and relatively strong in early childhood become less so as the age increases, so that when nephroptosis occurs the adrenal never participates in the descent of the kidney. In women the paravertebral fossæ are more cylindrical and shallow and more open below than in men. Since the intra-abdominal pressure depends to so large an extent on the tonicity of the abdominal musculature it will be seen that the frequency of nephroptosis in women is explained by their greater subjection to conditions causing relaxation of the abdominal walls.

The kidneys, as we have seen, enjoy a certain range of motion in an up-and-down direction. The right kidney normally lies from one-half to one inch lower than the left and its excursion during inspiration is caused by pressure transmitted through the liver, while the left kidney is acted upon directly by the diaphragm. A condition that would decrease the capacity of the upper abdomen or increase the downward

and forward thrust of the diaphragm would tend to cause a displacement of the kidneys. Enlargements of liver and heart have been referred to as being responsible for some cases of nephroptosis.

The close anatomical relations between the innervation of the kidneys and the other abdominal organs, and with the vasomotor system and visceromotor apparatus that have a part in maintaining the kidney in normal position through intra-abdominal pressure and physical "tone," also serve to produce nephroptosis when conditions affecting the nervous system disturb their interaction.

Etiology.—Many causes have been assigned in explaining the etiology of movable kidney. The *congenital type* is extremely rare and must be explained on the basis of embryological defects or anomalies. Various other associated congenital defects are usually demonstrable in these cases. The causes of the common or *acquired type* may be conveniently grouped as predisposing and active.

Congenital Predisposition.—This may be taken to account for those instances where several cases of movable kidney are found in a single family, and speaks for a general weakness of the supporting structures of the kidney, a condition necessarily associated with splanchnoptosis, according to Glénard. It will be seen, however, in discussing body form, an hereditary factor, that this probably plays a far greater part than the supporting structures in determining abnormal mobility of the kidney.

Body Form.—The type of individual in whom the condition occurs most frequently may be described as small and thin, with a long, flat and narrow chest, increased obliquity of the ribs and a narrow subcostal angle. The lumbar curve is poor and flat (less shelf action to support viscera of upper abdomen). The renal fossæ are shallow, wide, and more vertical. We have seen above how the conformation of these fossæ peculiar to women may predispose to nephroptosis. Much undue importance has been attached to tight lacing as an etiological factor. It is conceivable that corsets by compressing the eleventh and twelfth ribs might tend to force the kidneys forward and downward from their fossæ, but this would require a degree of compression rarely practised, and in general the compression of the lower abdomen and at the waist line would tend to hold the kidneys in the normal position. As a matter of fact, it has been found that movable kidney is almost as prevalent among races of women who wear no corsets as it is among the "fashionable" civilized races.

Child-bearing and Pelvic Tumors.—The increase of the intra-abdominal capacity following parturition or the removal of large tumors (also ascites) reduces the very important factor afforded by intra-abdominal pressure and so may predispose to nephroptosis, especially if the individual leaves her bed or indulges in physical exertion before restoration of the tone of the abdominal walls has occurred. In the parturient also, the relaxation of the pelvic floor is an added factor.

Scoliosis of the sort so common in school-girls from the habit of carrying books under the arm or that arising as the result of faulty position in sitting or standing may cause a shallowing of the pararenal fossa and so predispose to the development of nephroptosis. The more severe forms of scoliosis accompanying spinal disease frequently result in increased mobility as well as misplacement of the kidney.

Enlargements of the Kidney.—It has been noted by some observers that at the time of menstruation the kidneys participate in the general visceral congestion and at such times are actually enlarged and are consequently of greater weight. This observation has been advanced in explanation of the greater frequency of movable kidney in women, though it probably plays a most unimportant role. Enlargements and increased weight due to renal tumors, cysts, stone, pyonephrosis, and hydronephrosis are also mentioned as probable factors in some cases. In the latter condition it is generally believed that the mobility generally precedes and causes the hydronephrosis, but it is conceivable of course that the mobility also may be increased thereby.

Rapid Absorption of Fat.—It has been seen that the perirenal fat capsule plays an important part not only in serving as a protecting cushion and as a "lubricant" for the normal movements of the kidney, but also serves to bolster it in position. The fine connective-tissue fibers running from perirenal fascia to renal capsule are kept taut by the adipose tissue, but when, for any reason, the fat is absorbed these fibers are relaxed and the kidney may enjoy a much greater range of motion. Any condition leading to rapid emaciation or cachexia will produce this state of affairs, among which may be mentioned some cases of malignant disease, gastro-intestinal lesions, and long-continued fevers. Movable kidney has followed misguided efforts "to reduce" by some of the widely advertised methods, especially those in which the administration of thyroid extract plays a part. The emaciation often accompanying the development of neurasthenic conditions also probably has much to do with the prevalence of nephroptosis as well as visceroptosis in such cases.

Visceroptosis.—While a consideration of the anatomical relations of the kidney does not make it appear probable that gastroptosis or splanchnoptosis would of themselves play a very real part in causing or permitting increased mobility of the kidney by direct drag or otherwise, the conditions, anatomical and constitutional, that predispose to visceroptosis apply also to nephroptosis. Under body form we discussed the visceroptotic type and noted the general weakening of the factors that act in the support of the kidney, as well as of the other abdominal viscera. The nephroptosis then is probably a coincidence rather than a result of the visceroptosis.

In chronic constipation with overloading of the colon and cecum it is quite possible that some direct pull may be exerted on the attachment of the right kidney in particular and so increase its range of motion.

Trauma.—Of the active causes of movable kidney trauma of an acute or chronic type comprises the list. Many cases date the onset of their renal condition from the time of the receipt of some injury, such as a fall from a horse, slipping on the stairs and landing forcibly on the buttocks. Blows and crush injuries also have accounted reasonably well for some cases in women, in whom the greater delicacy of tissue makes displacement more probable, while in men the kidney itself is more usually injured. Sudden severe muscular exertion, as in lifting, or in athletic contests, may be an etiological factor, while the forcible efforts at stool in chronic constipation or the chronic cough in some of the lung and heart diseases may by reason of the active downward push of the diaphragm throw strain on the renal moorings. The traumatic loosening of the kidney may, as in the latter group of cases, be due to a slow gradual stretching of its attachments or may, as in the former group, be due to a sudden rupture of its fascial and peritoneal coverings.

Pathology.—Mobility of the kidney of an abnormal degree may exist for years without giving rise to any symptoms whatever and in such cases the organ itself would remain entirely free from anatomical changes of a pathological nature. In many cases of this sort when the organ has been examined at autopsy a moderate irregular fibrosis of the capsule has been found, together with some thickening and lengthening of the fibrous strands connecting perirenal fascia and capsule. If, however, the patient has had renal "crises" or other severe symptoms, various changes in the organ are to be noted. Kinking of the ureter or strangulation of the vascular pedicle lead respectively to hydronephrosis in the one, with the accompanying changes noted under that lesion, and various interstitial and parenchymatous changes in the other due to the chronic passive congestion and other disturbances in the blood supply. Not infrequently the catheterization of the ureter on the affected side reveals some degree of nephritis, as shown by the presence of albumin and casts or even of blood in the urine. Rather less than 10 per cent. of movable kidneys show hydronephrosis of some degree. In such cases the kidney itself and the pelvis are usually somewhat flabby. One of the relatively frequent findings is a persistent fetal lobulation of the organ. This is in accordance with the supposition that most cases of nephroptosis hark back to a congenital predisposition and certain defects of an embryological nature.

The vascular pedicle of a movable kidney is usually longer than normal. Often it is found that the arteries come off from the aorta at a point lower than usual. The ureter also frequently shows some degree of kinking or assumes an S-shaped position. Unless the vitality of the movable kidney has been lowered by interference with its ureter or blood supply there is no reason for assuming that it is more predisposed to stone formation, infection, or hydronephrosis than are normally fixed organs. The effects of a movable kidney on surround-

ing organs are at times quite marked. The drug transmitted to the duodenum may lead to marked dilatation of the stomach, obstruction of the bile passages, and even to interference with the intestinal flow, while through the nerve reflexes marked functional disturbances of the gastro-intestinal tract may ensue.

The increased range of movement in an up-and-down direction is, in the more marked degrees of mobility, accompanied by rotation about a vertical axis, and the external border comes to lie more anteriorly, about a transverse axis, permitting the upper pole to incline forward, and in the form of an arc, with a pedicle as radius, so that when in its lowest position the hilum looks almost directly upward.

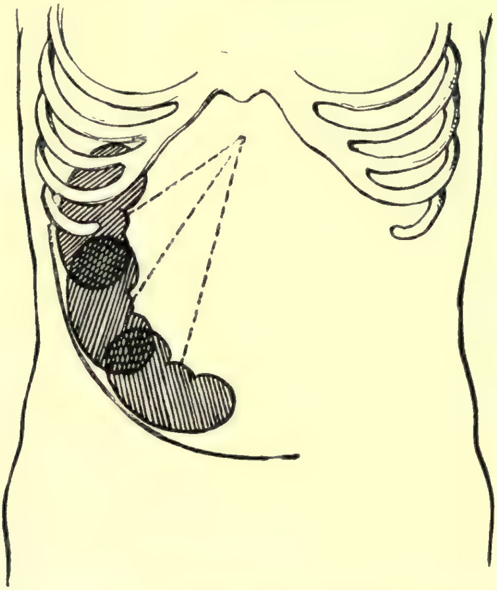

FIG. 169.—Movable kidney of different degrees, indicating also rotation about an arc with the pedicle as radius.

Symptoms.—As noted above, a movable kidney of marked degree may give rise to no symptoms whatever. When symptoms do arise, they may be of the so-called renal type, may concern the gastro-intestinal tract, or may be neurotic, or there may be any combination of these. The onset may be gradual or of sudden development following some exertion.

Pain.—Pain is one of the chief symptoms and is referable to the kidney directly. It may be of an indefinite nature, more of a sense of weight or discomfort and weakness in the renal region than actual pain. Some complain, before they know of the nature of the trouble, of a sense of something loose inside. The more severe type of pain is usually described as dull and dragging, or at times colicky in nature,

usually worse on walking, exertion, or in the upright position and during menstruation, and is relieved by lying down or by rest in bed. The discomfort or pain may be of a chronic or continuous nature or there may be distinct attacks. In some cases the symptoms appear only when the patient is run down or at the menstrual periods.

In 1864 Dietl described the symptom-complex presented by the "renal crises" which have since borne his name. These attacks resulting from the twisting of the pedicle of a movable kidney are characterized by pain of a most severe type. This may arise either from obstruction of the ureter and a rapid distention of the pelvis and calyces by the retained urine, or may be due to the marked congestion of the kidney and tension on its capsule because of interference with the venous outflow. With the violent pain, chiefly in the lumbar region, there are constitutional symptoms, such as nausea, vomiting, chills and fever, and the general evidence of shock. There is usually tympany, spasm of the overlying muscles, and during the attacks oliguria or even anuria may be present. These pain attacks may last merely for a few minutes or may persist for a couple of days. They usually cease abruptly after the untwisting of the pedicle by postural or manipulative measures (Edebohls) and in case the ureter has been obstructed, are followed by polyuria. In most cases albumin and even blood may be found in the urine after such an attack, which corresponds to the type of attack described for intermittent hydronephrosis. During the attacks the kidney is usually found to be enlarged and very tender to palpation. The pain is usually in the loin and directly over the kidney in front, but in some cases is referred down the course of the ureter into the labia or testicle and into the thigh.

Gastro-intestinal.—The gastro-intestinal symptoms caused by movable kidney are for the most part due to the renal pain acting through the sympathetic and central nervous systems, or are the result of direct mechanical action, such as drag on the mesentery or pressure on the mesenteric vessels, or pressure on the duodenum leading to interference with its emptying and to the dilatation of the stomach. So many of the intestinal symptoms attributed to a movable kidney are found with equal frequency when splanchnoptosis alone is present that care must be exercised in differentiating the conditions. Among the symptoms frequently noted are anorexia, dyspepsia, nausea, flatulence, constipation, duodenitis and mucous colitis. At times gastric ulcer and gastric atony are closely simulated. The pain, however, bears no relation to meals and vomiting does not relieve it. Ulcer may be an associated condition and is to be differentiated by analyses of the gastric contents and other methods used for diagnosing that condition. The cecal stasis present in some cases is said to predispose to appendicitis. Jaundice is occasionally a marked symptom and may be due to mechanical effects on the duodenum or to kinking of the common duct by reason of a hepatoptosis. Cholecystitis and

cholelithiasis may be associated with the renal lesion and be the actual cause of the jaundice.

Nervous.—Neurasthenia is so often a concomitant of movable kidney that the question often arises as to whether it is the cause or the result of the lesion. Not a few cases showing other symptoms of movable kidney in a severe degree are quite devoid of the manifold symptoms indicating a neurasthenic state, so that a preëxisting neurotic taint is presumable when they do appear. About one-third of the cases of movable kidney present nervous symptoms and about half of these cases may have the symptoms cured by fixation of that organ. Simple marked nervousness, irritability, and restlessness are frequently complained of, or the symptoms may be those of true hysteria or neurasthenia. Fits of depression, loss of will-power, palpitations, flushings, and deficient vitality, as well as headaches, widely distributed pains and neuralgias are complained of. The psychic disturbances frequently do not manifest themselves until after the patient has been informed of the condition present. In all probability, in those cases where the nervous symptoms are the result of the lesion, the underlying cause must be ascribed to the pain. It must be remembered, however, that the type of individual predisposed to movable kidney is also the general type that is regarded as of a neurotic tendency so that care must be exercised to guard against precipitating attacks of nervous disturbance by carelessly giving information as to the lesion present.

Diagnosis.—The degree of abnormal mobility of a kidney does not determine the severity of the symptoms that may be attributable to that lesion. As a rule, however, a mobility of less than the third degree seldom causes severe symptoms. The diagnosis of this condition is determined by palpation and the finding of a movable tumor in or close to the kidney region, of the general shape and size of that organ, which is usually readily replaced into the renal fossa. After this finding it is to be determined whether the symptoms complained of actually are caused by the abnormal mobility.

The methods of physical examination have already been referred to in the section on hydronephrosis. It must be added that the kidney is to be sought for with the patient in the upright position as well as recumbent. Have the patient stand and lean forward, resting the hands on the bed or other firm object, and palpate, beginning in the iliac fossa by working the hand upward toward the costolumbar angle. Slight degrees of mobility are detectable only in this latter region and during the inspiratory phase. In more marked cases the smooth, rounded form of the kidney may be felt slipping up and down under the examining hand during respiration, or, in the extreme cases, it may be fixed in the low position and completely outlined by pressing with the finger above its upper pole. A dilated gall-bladder may be mistaken for kidney, but its position, outlines, and limited range of motion aids in the differentiation. Cysts of the liver, super-

numerary or floating hepatic lobes, and carcinoma of the pylorus or head of the pancreas have been mistaken for movable kidney.

In the question as to whether the mobility is the cause of the symptoms, the duplication of the pain and other symptoms produced by injecting the pelvis of the kidney through a ureteral catheter is of great assistance. Pyelography with the pictures taken in both the upright and recumbent postures is of great value in showing the extent of mobility, as well as in differentiating it from other lesions. The urinary examination is of value chiefly during or immediately after an attack. The changes are usually very transitory, and are attributable to twisting of the pedicle or kinking of the ureter.

Treatment.—The discovery of an abnormally movable kidney in the absence of any symptoms from it or evidence of necessity for treatment, should not, in the majority of cases, be lightly communicated to the patient because of the danger of precipitating a train of psychic symptoms in an individual of poorly balanced nervous system. General advice as to building up the general health, fattening up, and the avoidance of straining or lifting is called for so as to prevent an increase in the condition or the development of symptoms. For cases having symptoms, the treatment may be either *palliative* or *operative.* The former is appropriate for mild cases and should be tried for not over six months, if no relief is obtained, lest the strain on the nervous system lead to the development of neuroses. Spontaneous cure often follows the rest cure and the fattening process and occasionally pregnancy causes a remission of symptoms. Where neurasthenia is already present suggestion is often of help. Efforts must be made to correct the effects of an accompanying splanchnoptosis and to treat a chronic cough from heart or lung disease. Aside from the rest cure and fattening already advocated, other hygienic measures, such as electricity, massage, and certain forms of mild exercises are to be recommended. The most dependable and satisfactory form of palliative treatment consists in supplying some form of mechanical support for the abdominal wall so as to increase the intra-abdominal pressure. This may be accomplished by a well-applied bandage or woven elastic belt, or by strapping with adhesive plaster. The pressure should be applied over the entire abdomen and in an upward, backward direction. The use of special kidney pads or trusses as a direct support for the organ is not to be recommended, for they are seldom successful and are capable of doing considerable harm. Where the attacks are intermittent the belt or bandage should be worn as a prophylactic against their recurrence.

The *operative treatment* is indicated in the presence of severe symptoms, a painful wandering kidney, intermittent hydronephrosis with permanent dilatation of the pelvis, hematuria, or threatening secondary disease of the organ. When neurasthenia of less than a year's duration is present and is aggravated by movable kidney, operation is indicated. Beware of operating on a neurasthenic of long standing when definite renal symptoms are not present. Operation in such

cases is useless and may lead to the operation "habit." In cases having also a splanchnoptosis, operation on the kidney is of little use. Cases without symptoms should of course not be operated upon.

The object of operation is to explore the affected kidney and to fix it firmly in place without injuring the parenchyma. Nephrectomy is not to be considered unless there is failure to obtain relief by fixation. Even repeated attempts at fixation are preferable to removal of the organ. Hahn attempted such an operation in 1881 and called it nephrorraphy. In 1899 Le Dentu applied the term nephropexy, which is in more common use today. The chief aim in these operations is to cause firm fibrous adhesions between kidney and posterior abdominal wall.

The list of operations devised for the cure of movable kidney is a long one. They fall into two general groups. The first group comprises those methods aiming to produce a mass of granulation and scar tissue about the organ to cause fixation principally by this means, and consists in the irritation or scarification of the renal capsule and the surrounding tissue and the support of the kidney in the desired position by packing, by loops of gauze or ligature material passed about the poles of the kidney and left *in situ* until fixation has occurred by granulation. The second group includes those operations that are more truly a fixation and are characterized by actual suturing of the organ into position against the lumbar fascia and muscles by sutures passed through the substance of the kidney or merely through its capsule, either with or without varying degrees of decapsulation to promote adhesions to the surrounding tissues. The process of decapsulation not only does not injure the kidney, but is even supposed to benefit it by increasing its circulation. The decapsulation may be complete, that is, after incision along the convex border it is stripped well back to the hilum both front and rear, or it may be stripped from the posterior surface only, or narrow strips may be raised from various parts of the surface and the anchoring sutures passed through the strips or leaves of the capsule and on into the muscle of the posterior and lateral wall of the abdomen.

The operations are performed by choice through the lumbar incision. Care must be exercised in cutting down to the kidney not to injure the last dorsal nerve which runs along the posterior portion of the incision close to the quadratus lumborum muscle. After the incision and separation of the muscles the perirenal fatty capsule is exposed and must be removed, particularly from the posterior surface of the kidney, for any interposition of adipose tissue prevents efficient adhesions between the approximated surfaces. In general the rule is to fix the kidney in as high and as nearly the normal position as possible. The position attainable of course depends on the length of vessels and ureter and upon the level at which the vessels come off from their trunks. In some cases anchoring sutures are placed from the upper pole of the kidney around the twelfth rib, but the frequently marked

mobility of this rib with respiration renders the method inadvisable in some cases.

Following operation the patient should be kept flat on the back for about four days and the foot of the bed should be raised six inches on blocks for about ten days in order to utilize gravity in aiding to keep the kidney in proper position. The stay in bed should be at least three weeks. A firm binder or belt as in the palliative treatment should be worn immediately after operation and for several months thereafter.

It is manifestly a waste of effort to operate for the kidney condition and expect a permanent cure when it is merely a single manifestation of a general process, such as visceroptosis, or in old cases of neurasthenia. Efforts directed toward correcting the general condition should first be made. Exceptions to this are of course those cases with severe acute symptoms such as "crises" or where a dilatation of the pelvis threatens to injure the kidney severely. The mortality from these operations is decidedly less than 2 per cent. Postoperative complications are few and the permanent cures average about 70 to 75 per cent. Many cases are reported to have been cured by second operations.

INJURIES OF THE KIDNEY.

Of the traumatic injuries treated in clinic, only about 1 in 1000 was found by Küster to involve the kidney, while in nearly 3000 autopsies only 13 renal injuries were found. In all surgical diseases of the kidney, injuries comprise less than 8 per cent. It is probable, however, that these figures do not indicate the frequency of renal injuries, even of relatively severe degree, because, as will be seen later, a large group of the cases may be classified as benign, inasmuch as they are recovered from without operation or without even hospital or clinical treatment.

The statistics show that the lesions are more common in males (93 or 94 per cent.), and on the right side than on the left. The lesion is rarely bilateral. From the anatomical stand-point the kidney is particularly well protected from trauma, and in general considerable violence is needed to produce injuries. Its position in relation to the lower ribs and the vertebral processes, however, render it liable to compression between the ribs and the firm neighboring structures in certain accidents where forcible flexion of the body or compression of the lateral walls is exerted. Moreover, on account of its fluid content and relatively inelastic capsule, the organ is susceptible to the explosive action of hydrostatic pressure. The comparative infrequency of the lesion in women is accounted for both because they are less often subjected to injury and because of the greater protection afforded by their wider, higher iliac crests and greater abundance of fat. Their kidneys are more likely to be displaced than to be injured by violence. The wearing of corsets may also play some protective role.

Injuries without External Wound.—Etiology.—Renal injuries may be grouped according as to whether they exist with or without external wound. The injuries of the *subparietal* or *subcutaneous* group are caused by the *direct violence* of blows or kicks directly over the loin or lower ribs, by falls across narrow bodies, such as beams, by crushing or "run over" accidents, or by the compression in "buffer" accidents. *Indirect* violence, such as sudden severe muscular effort with violent flexion of the body or in falls upon the feet or buttocks may cause injury by compression against the twelfth rib or transverse process of the first lumbar vertebra. The lesion in the kidney usually consists of a fissure or fissures in the parenchyma or capsule or both, radiating from the hilum in the transverse axis of the organ. The factors determining the degree of injury are the amount of force, the point of its application, and the resistance encountered.

Pathology.—The lesions suffered are classified according to degree as follows:

1. Tears of the fatty capsule without injury of the kidney. There is often a considerable collection of blood in the perirenal tissue which may become absorbed, encysted, or organized.

2. Contusion of the renal parenchyma may result in localized subcapsular ecchymoses or hemorrhages, which usually absorb or become small areas of scar tissue. If infection is present, suppuration may result.

3. Interstitial rupture of the parenchyma may rarely occur without serious tears of the capsule, but tearing of the capsule without parenchymatous lesion is hardly possible. The usual result of such injury is extensive extravasations of blood into the kidney substance and, if capsular tear is present, into the perirenal tissue. These tears usually radiate from the hilum and in a transverse direction near the lower pole and on the anterior surface of the kidney. Blood may enter the pelvis by effusion, or be carried there by the urine.

4. Rupture of the parenchyma and capsule may extend into the calyces or pelvis and the extravasation will be a mixture of blood and urine with also an increased tendency to infection. When the rupture is complete, that is, includes capsule, parenchyma and pelvis; the perirenal extravasation is an added complication. Such ruptures may be of sufficient extent to completely sever a pole of the kidney and open the larger arteries near the hilum. The perirenal hemorrhage and extravasation, limited as it is above, front, and rear by the perirenal fascia may extend downward toward the iliac fossa and pass through the inguinal and femoral canals to thigh, scrotum and labia. At times there is no urine mixed with the blood, even in severe rupture of the pelvis, because of the anuria produced by the trauma. Fatal hemorrhage may occur or it may be stopped by operation or by clotting. The subsequent history of the extravasated blood may be absorption, organization, cyst formation, or, with infection added, suppuration.

5. In severe crush injuries fragmentation or pulping of the kidney may occur. This is usually fatal unless operation to control the hemorrhage is prompt.

6. Rupture of the peritoneum with intra-abdominal hemorrhage or extravasation of urine and rupture of the vascular pedicle is a rather unusual lesion. Both are rapidly fatal unless immediate operation is performed. The peritoneal tears are more common in children under ten years of age because of the paucity of perirenal fat.

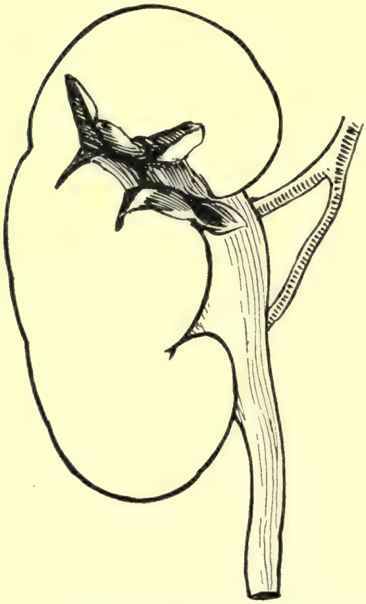

FIG. 170.—Rupture of kidney. Tear extends directly into pelvis.

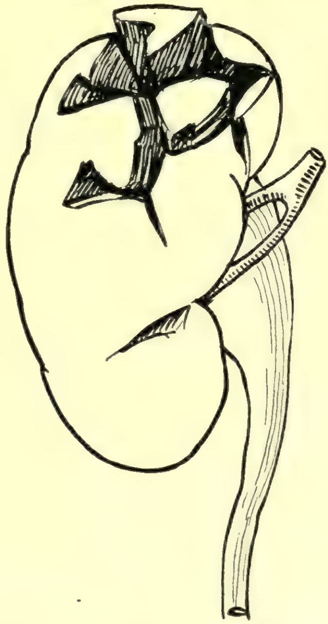

FIG. 171.—Rupture of kidney of severe grades, with tearing through capsule and parenchyma. Fragmentation.

If no infection intervenes the lesions of the first three degrees usually heal promptly by cicatrization. Laceration of the parenchyma always results in an area of scar tissue resembling a healed infarct. There is always a zone of renal parenchyma on either side of the fissure that loses its functional capacity and becomes fibrosed. This fibrosis extends into the blood clot lying within the fissure itself. Defects of renal continuity are thus repaired, but there is no regeneration of the functional structures.

Symptoms.—As in traumatic injuries of the abdomen in general the severe subparietal injuries of the kidney are usually accompanied by some degree of shock as an initial symptom. The shock is more the result of disturbance of the abdominal nerves by the external

violence than of the injury of the kidney itself. In some cases, however, the symptoms may not come on for several hours and may then be the result of hemorrhage rather than shock.

In addition to *shock*, with its rapid pulse, weak respiration and hypothermia, the cardinal symptoms of renal injury are *pain*, *hematuria*, *hematoma*, and as a later symptom, *changes in the urine*. The pain is usually severe and begins with the receipt of the injury. It may be due to the local bruising of the tissues of the abdominal wall or to fracture of the ribs. When it is due to the lesion of the kidney it is usually conducted along the course of the ureter and causes retraction of the testicle. Pain of slower onset may arise as the result of the extravasations of blood and the resulting tension in the tissues. Pain of a colicky nature is due to the passage of blood clots down the ureter or to obstruction of the ureteropelvic junction. The renal region is exquisitely tender to palpation and the muscles in that region are in a state of rigidity.

Hematuria.—In 90 to 95 per cent. of the cases hematuria is present. It is the most characteristic symptom of renal injury. In a few cases it is not present or its presence is not discovered early because of the inhibition of renal function that sometimes accompanies the injury. When merely the fatty or the fibrous capsule is torn without actual injury of the parenchyma, blood may be absent from the urine. Blood may be absent also if the pelvic outlet is quickly blocked by clots or the ureter is torn across.

In the mild cases the only symptom directing attention to the kidney may be the presence of blood in the urine. In about half the cases it disappears within a week, but may persist for a long time and even be the cause of death. Secondary hemorrhage may occur after many days or a couple of weeks as the result of exertion or infection. Where large quantities of blood pass into the bladder, clotting there may lead to distention or tenesmus and requires catheterization and suction or even cystotomy. It is necessary in some cases to distinguish whether the blood comes from the kidney or from the bladder. This may be done by emptying and washing the bladder when, if the kidney is the source, the repeated washings will be relatively free from blood, while in bladder lesions they will be well stained because of the local disturbance caused by the washing.

Hematoma.—The extravasation of blood or blood and urine into the perirenal tissues in severe lacerations of the kidney gives rise to the tumor or hematoma in the flank. It is first noted as a non-movable dulness in the flank and later as it increases in size and the muscle rigidity of the part decreases it may be palpated as a tumor, larger than the normal kidney, that does not move with respiration. For this reason it should be distinguishable from renal tumor or hydronephrosis. In some cases the mass can be made out within two hours of the receipt of the injury, but it may be masked by muscle rigidity or may actually be of slow development. Extravasations of blood into

the mesentery may cause intestinal symptoms by irritation of the nerves.

Urinary Changes.—Oliguria and anuria may be an early symptom as the result of sympathetic inhibition of both kidneys and may last for a few hours or lead to uremia and death. It thus may retard the appearance of the urine at the external wound and so delay the diagnosis of renal injury. Polyuria frequently follows the oliguria. Traumatic nephritis alluded to above may be a persistent symptom.

Complications.—Hemorrhage of severe grade, especially in cases where the peritoneum has been torn, is the most immediate and dangerous complication and demands prompt operation. Infection is to be feared from the third day on. The involvement may be peritoneal or it may be confined to the kidney itself or occur in the perirenal extravasation. The organisms may reach the spot either by way of the blood stream or by migration from the bowel or from the urinary passages.

The local infection and suppuration demands incision and drainage or in some cases may call for nephrectomy. Traumatic hydronephrosis is discussed in the section on hydronephrosis. It is the sequel of injury to the pelvis or ureter, and may develop long after the receipt of the injury as the result of scar contraction. Movable kidney may follow trauma.

Not infrequently the liver, spleen, bowel, or other abdominal structures suffer damage in conjunction with the kidney and add the factors of hemorrhage and peritonitis to the picture. Fractures of the ribs, pelvis, or spine are not infrequent. Traumatic aneurysm of the renal vessels has been reported. The shock, anuria, uremia, and retention have been spoken of before as complications.

Treatment.—Renal injuries of moderate degree tend to recover spontaneously, but expectant treatment with rest in bed for at least forty-eight hours should be insisted upon in all cases until the dangers from possible immediate complicating factors are over. In more severe cases the region should be immobilized so far as possible and ice-caps used, and the patient kept quiet and comfortable with the free use of morphin. Shock and the effects of hemorrhage must be met with appropriate measures. The evacuation of the bladder must be cared for, and the patient should be kept in bed for about two weeks after the cessation of hemorrhage.

Operative measures are indicated in severe hemorrhage, both of the immediate and of the persistent type, in suppuration, in peritonitis, and later if hydronephrosis or pyonephrosis occurs. In general, the operation necessarily must be of an exploratory nature. Through the lumbar incision it is possible to expose and repair lacerations of the renal capsule, parenchyma, or pelvis with catgut sutures. Clots may be cleaned out and drainage provided to ward off infection. In the cases of severe laceration damaged portions of kidney may be removed

and the bleeding controlled by ligation, suture, or packing. The pelvis may be opened also and cleared of clots and closed or drained. When the kidney is damaged beyond repair nephrectomy should be performed at once. Severe damage of its blood supply may call for the same procedure. Persistent or recurrent attacks of bleeding may require nephrectomy to save life.

Results.—While the expectant treatment alone yields satisfactory results in the majority of uncomplicated cases (70 per cent.), the operative treatment of the more severe injuries is more encouraging and increasingly good reports are being published. Early and accurate diagnosis and early exploration in appropriate cases is the watchword, both for the purpose of stopping hemorrhage and to counteract the common causes of infection.

Renal Injuries with External or Open Wound.—The renal injuries belonging to this group are comparatively rare. Only about 100 cases of incised or stab-wound injuries of the kidney are on record. They are incised or lacerated, punctured or stab wounds, produced by knives, swords, bayonets, and the projectiles of firearms (bullets and shell fragments). Reports of wounds of the kidney caused by a hay-fork handle and by a wagon pole are on record.

Pathology.—The situation and direction of the external wound determines the nature of the serious complications that so often accompany the renal wound. The liver, pleura, spleen, and intestine are most often involved. The size of the wound determines the presence or absence of prolapse of the kidney. From the situation and direction of the wound, and the nature of the instrument causing it, the probability of renal injury must be inferred. In the presence of small external wounds the escape of urine from them is of course diagnostic of an opening into the kidney, its pelvis, or ureter. Large wounds may reveal the kidney itself and the injury it has sustained. All wounds belonging to this group must be regarded as potentially infected and in the projectile cases the possible presence of a foreign body must be considered. In general, the symptoms referable to the kidney are similar to those described for subcutaneous injuries. The amount of actual injury sustained by the kidney itself, and consequently the symptom-complex produced, varies considerably. When the capsule and cortical substance alone are wounded there is no escape of urine from the wound, and hematuria may be very slight and transient or entirely absent. The perirenal accumulations of blood and urine are also unusual unless the wound be in the nature of a long, narrow tract. The frequency, also, of openings into the peritoneal or pleural cavity renders the accumulation less frequent. The symptoms of shock, hemorrhage, and hematuria referable to the kidney vary according to the nature of the injury. Pain is usually a less-marked symptom than in cases of the subparietal group and is not, as a rule, referred down the ureter. There is less chance of tension arising from extravasations

into the tissues, and the nature of the wound is not so conducive to local pain external to the kidney. However, the more frequent development of infection adds a fertile source of pain.

Prolapse of the kidney may, but rarely does, occur through a large wound. The prolapse may be partial or complete, occurring at once or following a coughing spell or straining effort at a later time. When the intestine has been perforated flatus may escape with the blood and urine through the parietal wound.

Bullet and Projectile Wounds.—The high-velocity modern bullet enjoys the distinction of producing wounds that are frequently uninfected and if kept sterile they may heal with considerable rapidity. Allowance must be made of course for the occasional "explosive" effect of these bullets on the kidney with the resultant disintegration and bruising of the tissues. This increases the liability of infection as well as causing most severe lesions with marked hemorrhage, urinary extravasations, etc. In such cases early operation is imperative. Pistol or low-velocity bullet wounds of the kidney do not, as a rule, cause the more serious lesions, unless they themselves act as foreign bodies or lead to the carrying of bits of clothing or other infected material into the wound.

Hemorrhage from gunshot wounds is not usually severe unless one of the larger branches of the renal artery is injured, but occasionally the primary hemorrhage is rapidly fatal. The injuries of other organs and the infection of the wound are the principal causes of death. The latter may result from improper care of the external wound, foreign bodies, extravasations of urine and unclean catheterization.

The mortality from gunshot wounds of the kidney in the American civil war was 69.4 per cent. In the Franco-Prussian war it was 53.3 per cent. This was in the period of lead bullets and lack of asepsis. In civil life Küster's statistics show a mortality of 28.4 per cent. The uncomplicated cases, as has been indicated above, heal rapidly. Secondary hemorrhage does occur rather frequently about eight days after bullet wounds. Such bleeding may show at the external wound, in the urine, or in the perirenal tissues.

In modern warfare shrapnel bullets and shell fragments play a conspicuous part. The wounds produced by these relatively slow-moving projectiles are frequently of the lacerated type. Bits of clothing are very likely to be carried into the tissues and the contact with the ground that they frequently experience before producing the wound makes the occurrance of infection very great.

Diagnosis.—The position and direction and nature of the wound tract must be considered with the symptoms of shock, internal hemorrhage, and escape of urine for establishing a diagnosis of renal involvement in these cases. The x-rays are valuable in locating a bullet or shell fragment.

Treatment.—The expectant treatment with aseptic precautions is sufficient in the majority of uncomplicated cases without severe

hemorrhage either external or internal. Operative measures are directed toward the control of hemorrhage and urinary leakage by ligation or suturing the renal or pelvic defects and to prevent infection by providing free drainage and by removing foreign bodies. It is well to excise the bullet tract if possible. Nephrectomy is at times advisable. Complicating lesions of the abdominal viscera, peritonitis, etc., are to be treated according to general surgical methods. A prolapsed kidney is to be cleansed, replaced, and a fixation operation performed. (See Movable Kidney.)

CHAPTER XII.

INFECTIONS OF THE KIDNEY.

BY EDWARD L. KEYES, JR., M.D.

THE ensuing chapter is concerned with the inflammations of the kidney, its pelvis and ureter, due to bacteria other than the bacillus of tuberculosis.

The borderland of such inflammations cannot be precisely defined. There is good reason to believe that in addition to those types of inflammation characterized by the appearance of bacteria in the urine in sufficient number to cloud this fluid (producing the condition known as bacteriuria), or of sufficient virulence to produce pus (pyuria), there are others that have not been sufficiently studied for permanent classification.

These may be classified in three groups: viz.:

1. Bacterial lesions resulting in acute or chronic nephritis without gross evidences of bacteriuria.

2. Bacterial lesions underlying the formation of "primary" or "aseptic" calculus.

3. Bacterial lesions characterized by the constant presence in the urine of the ordinary pathogenic bacteria in so small a number as to produce no visible bacteriuria, to evoke no pyuria, to elude identification by centrifuge and stain, and to be discerned only by culture.

1. Dick[15] confirmed the observation of previous investigators that cultivation of bacteria from the urine must be guarded by the most minute precautions against contamination, and that the familiar urethral staphylococci and diphtheroid bacilli must usually be regarded as contaminations,[24] if found in urine supposedly derived from the upper urinary tract.

His original observations cover two classes of cases, viz.: (*a*) 5 cases with normal urine both macro- and microscopically, but suffering from focal infections (appendicitis, pyorrhea, arthritis, sinusitis), and (*b*) acute and chronic nephritis (20 cases). In each of these 25 cases he found bacteria other than the above-mentioned staphylococci and diphtheroid bacilli.

He enumerates fifteen different types of bacteria, none of them occurring more than once, excepting a small Gram-variable anaërobic bacillus (twelve times) and streptococci (fifteen times). The few animal experiments made by Dick appear to support his contention that the anaërobic bacilli can produce nephritis. Such experiments are suggestive, but require confirmation.

Grulee and Garde[22] report 6 cases of acute nephritis associated with tonsillitis, characterized by fever; urine containing albumin, casts, blood, and leukocytes; and a Staphylococcus albus in 3 cases, a streptococcus in 2 (two sterile urine cultures). Blood culture was once negative and once revealed staphylococcus and once streptococcus. The throat cultures in 3 cases corresponded with the urinary cultures. The infection was of brief duration and never showed the characteristics of ordinary pyelonephritis.

Such observations as these will stimulate further investigation.

2. It has long been recognized that phosphatic calculi are secondary to inflammation caused by urea-splitting ammoniogenic organisms; but we have as yet no certainty as to the precise cause of primary or "acid" stones. There are various reasons for believing that these also are due to bacterial changes. Indeed, one author has been so bold as to maintain that oxalate stones form only in urine that contains bacteria with flagella: but such suppositions await confirmation. Cabot[8] remarks that were infection the cause of stone it should be much more common in women than in men, which it certainly is not.

3. The presence of bacteria in apparently normal urine apart from the contaminating bacteria already mentioned has been amply proven. Pathogenic bacteria are also found in urine that presents no pathological characteristics. Thus, after an apparent cure of a recognized infection of the urinary organs—after the symptoms have subsided, the pus has disappeared and albumin and casts (if they were present) are no longer to be discerned—the same pathogenic bacteria that were found in great numbers during the attack, may often still be cultivated from the urine. This is almost characteristic of Bacillus coli infection.

The length of time during which pathogenic bacteria may thus continue to grow in small numbers in the urinary tract without causing any appreciable lesions therein, we do not know. Apparently this period of latency may continue for years, and quite possibly some such condition antedates the acute renal suppuration of adults, which is often apparently spontaneous. For, as we shall see, young children are very subject to acute renal infections. They apparently recover completely in the great majority of instances, but often this condition of latent bacteriuria continues and may be a source of acute infections in later life.

Ross,[33] for example, made a bacteriological examination of 106 children's urines. Among 19 "normal" urines 8 were contaminated with Staphylococcus albus; 43 cases of Bacillus coli infection were found. Among these only 3 had a frank pyuria, 12 had a pure bacteriuria, and 6 revealed the bacilli only to culture (smears being negative).

Suter[36] goes so far as to affirm that once the Bacillus coli has established itself in the urinary tract there is small likelihood of its ever disappearing.

BACTERIURIA.

Bacteriuria is that condition in which the urine is clouded by bacteria and practically free from pus. (Bacteriuria is by no means always of renal origin. The precise observer will occasionally note fugitive bacteriuria in the course of a chronic prostatitis.) Doubtless a focus of parietal inflammation must be the source of bacteriuria, but the condition evokes no symptoms (other than urinary changes), and the precise reason why the urine should for days, or even months together, be clouded with bacteria, and yet either show no pus cells at all, or only very rare ones, has never been determined. But we do know that bacteriuria is usually but an incident in the course of a known inflammation of the urinary tract; usually a pyelonephritis, sometimes a prostatitis, rarely some other lesion.

Further, the bacteria found in bacteriuria are precisely those that are found in chronic pyelitis and prostatitis. Thus Suter[37] collected 169 cases of bacteriuria due to Bacillus coli, 13 due to staphylococcus, 9 due to streptococcus, and 6 to other bacteria.

Consequently, we must disagree with those who would make a separate malady of bacteriuria, and with those who insist that a pure bacteriuria is one in which no pus cells are ever present. Such an assumption can only be based upon proof that bacteriuria is an infection of the urine alone without any parietal inflammation. For this there is no warrant. We must place bacteriuria as a sort of connecting link between the conditions above mentioned (in which the urine contains bacteria so few that they can only be discerned by culture) and pyuria.

Bacteriuria may continue for an indefinite period; it may constitute the beginning or the ending of some recognizable inflammation. It is "total" if due to pyelonephritis, "partial" if due to a prostatitis (for in this case the urine obtained by ureter catheter from the kidneys is free from bacteria). Among Suter's personally observed cases 12 were total, 26 partial. The course and treatment of the "total" bacteriuria, with which we are now concerned, is that of mild pyelonephritis.

ETIOLOGY OF RENAL INFECTIONS.

In order to discuss fully the causes of renal infection, we may enumerate (1) the various bacteria found; (2) their routes of invasion; (3) the accessory or predisposing causes to infection.

The Bacteria of Renal Infection.—Infections of the kidney and of its pelvis and ureter (leaving apart the question of tuberculosis) are in the overwhelming majority of instances due to the Bacillus coli. Next in frequency stand the Staphylococcus albus and aureus. The Bacillus typhosus is found during convalescence in the urine of from 20 per cent. to 30 per cent. of patients with typhoid fever. It usually

causes little more than a bacteriuria. This and the gonococcus will receive special attention.

Scheidemantel[34] found among 100 cases of mild infections 76 typical coli (and 9 atypical), 3 proteus, 1 paratyphoid, 2 influenza, 1 diplococcus, 2 staphylococcus, 4 mixed colon and coccus, 2 streptococcus, 1 pyocyaneus.

The most recent and careful study of the bacteria of the infected urinary tract is that of David.[13] He isolated the following aërobic bacteria:

Bacillus coli	23
Staphylococcus albus	15
Staphylococcus aureus	3
Bacillus enteritidis	5
Bacillus alcaligenis fæcalis	3
Bacillus proteus	2
Bacillus pyocyaneus	2
Streptococcus	1
Pseudodiphtheria bacillus	1
Unidentified Gram-positive diplococcus	1
Pneumococcus	1
Influenza-like bacillus	1

The anaërobes isolated were:

Black pigment-producing bacillus	4
Gram-negative influenza-like bacillus	4
Staphylococcus parvulus	2
Gram-negative coccus	1
Bacillus funduliformis	1
Gram-positive staphylococcus	2

These organisms are derived from a conglomerate of infections of the urinary tract, many of them not involving the kidneys. When the urine is obtained directly from the kidney pelvis the Bacillus coli type occurs in about 90 per cent., the pyogenic cocci in about 5 per cent. of cases.

The importance of the anaërobes is quite undetermined, while the pseudodiphtheria bacillus and the Staphylococcus albus have probably no great pathological importance. It is to be noted that the infection is often a mixed one, and that the Bacillus coli is peculiarly likely to be associated with other bacteria. Thus in David's cases the Bacillus coli was found in pure culture only ten times.

The relative toxicity and clinical significance of the bacteria known to be pathogenic is by no means clear. Each has been isolated from the urine of mild infections as well as severe ones. But infections due to the pyogenic cocci seem less pertinacious than those due to Bacillus coli, and more likely to result in cortical and perinephritic suppuration, as described below.

In the clinical picture the accessory causes of infection so predominate as to make the precise nature of the infecting organism a matter of secondary importance.

The Bacillus Coli.—The Bacillus coli occurs in urine under a great variety of forms, both culturally and morphologically. Its virulence also appears to vary within wide limits. It may cause a bacteriuria or any of the known pathological changes in the kidney. It is much more common in the urine than in pyonephritic abscess. The Bacillus coli is found in acid or neutral urines; it often produces a peculiar odor, described as that of a dead mouse. It is very tenacious.

Pyogenic Cocci.—The virulence of the pyogenic staphylococci[20] and streptococci varies quite as widely as that of the Bacillus coli. It is characteristic of these organisms that they decompose urea into ammonia and water, thereby rendering the urine alkaline and occasioning the formation of phosphatic calculi. The irritating ammoniacal urine and the secondary calculus formation combine to render staphylococcus and streptococcus infections peculiarly virulent, yet in contrast with this they are much more frequently confined to the bladder than is Bacillus coli infection. When the infection is mild the cocci usually do not break up the urea to any great extent, and though they often make the urine alkaline, they are sometimes even found in acid urines. Thus among the cases observed and quoted by Goldberg 20 had acid, 2 neutral, and 16 alkaline urines. Perinephritic abscess is usually due to the pyogenic cocci.

Bacillus Proteus.—Among the many rarer bacteria found in urinary infections the Bacillus proteus, a Gram-positive organism, is noteworthy because of the virulent ammoniogenic infections caused by it. It is scarcely ever found in bacteriuria.

Routes of Invasion.—The routes by which bacteria invade the urinary tract are the following:

1. From the kidney (*a*) by the blood stream and, (*b*) by the lymphatics.
2. From the urethra (usually by instrumentation).
3. By irruption of a neighboring focus of suppuration.
4. By lymphatic or circulatory invasion at some point other than the kidney.
5. By operative or other trauma.

Renal or Descending Infection.—Modern methods of blood culture have abundantly proved that the circulating blood frequently contains living bacteria. These are derived from focal infections (abscesses) in various parts of the body or catarrhal affections of the various mucous membranes. It is now recognized that small, silent, unsuspected focal infections about the roots of teeth, in tonsils or adenoids, in the prostate and seminal vesicles, etc., are often the sources of bacteriemia; while among the catarrhal infections those of the colon and of the accessory nasal sinuses are most important. Every adult human being must at some time have had a bacteriemia from some one of these causes. This bacteriemia is often, perhaps usually, symptomless, the normal resistance of the organism being sufficient to conquer the infection. Yet the bacteria must frequently be presented to the

kidneys for excretion in considerable numbers. Doubtless the healthy epithelial cell will not transmit living bacteria: hence the fate of such bacteria in the kidney is doubtless either their destruction or the destruction of the epithelial cells in which they lodge. In the former case no recognizable lesions result; in the latter the lesion may be so slight and localized as to be unrecognizable, or it may produce a definite infection of the kidney.

What is true of the blood stream is equally true of the lymph. There is not sufficient evidence at hand to determine whether infection from the lymph or from the blood is the more common.

Ascending or Urethral Infection.—The female urethra and the anterior urethra of the male harbor such pathogenic bacteria (notably pathogenic cocci and colon bacilli) as are found on the adjacent skin or mucous membranes. Latent infection of the prostate and seminal vesicles is also extremely common. Furthermore, no lavage of the urethra can guarantee it free from such bacteria as may lie within its glands. Consequently, *any instrument introduced into the bladder may introduce with it certain pathogenic bacteria.* But it is abundantly proved that if the urinary organs are otherwise normal and no lesion of the mucous membrane is produced by the instrument, and there is no retention of urine, the bacteria thus introduced find no foothold and are simply ejected in the urinary stream. Clinical experience vouches for this and animal experiments by Albarran, Brewer, and many others amply confirm the fact. In short, *bacteria do not ascend spontaneously, or as the result of any instrumentation, from the urethra to the kidney, unless there is some accessory cause of infection* (see below). But it is equally well-known that, given the bacteria plus the accessory cause (*e. g.*, prostatic retention of urine with infection of the bladder), infection of the kidney promptly results.

It has been generally believed that bacteria reaching the kidney from the bladder ascend within the lumen of the ureter, possibly by actual extension of inflammation along the mucous membrane of this duct, possibly without inflammation. But recent observers whose work is summarized and apparently brought to a definite conclusion by the observations and experiments of Sweet and Stewart have shown that this surface extension of inflammation from the bladder to the kidney does not occur even when there is absolute stasis of the urinary stream. What we have long known as ascending infection of the kidneys must be one of two processes:

1. Either the bacteria are absorbed into the lymphatics about the bladder or prostate and thence enter the blood stream and are reëxcreted from the general circulation by the kidney (thus causing an actual descending infection), or else—

2. Direct lymphatic infection occurs along the lymphatics of the ureter to the kidney.

The latter theory is a very tempting one. Sweet and Stewart[38] summarize it as follows:

"1. An extensive network of lymph vessels and channels exists in the mucosa and submucosa, in the external coats of the bladder and the ureters, and in the entire structure of the kidney. This network in the ureter anastomoses freely with the lymphatics of the bladder at the one end and with the lymph apparatus of the kidney at the other end.

"2. An ascending infection travels through this lymphatic system, not through the bloodvessels of the ureter, nor through the lumen of the ureter. (*a*) The bloodvessels can be excluded because the veins of the bladder and the veins of the ureter, for the greater part, open into the general venous system, not into the venous system of the kidney. (*b*) The lumen of the ureter can be excluded, because if the lumen be open to infection the infectious process is traceable in the lymphatic system, not along the mucosa of the ureter; if the lumen be closed to infection the process extends to the kidney in the usual way; if the lumen be open to infection, but the lymphatics not in contact with virulent infection, there is no ascending infection; if the lumen be open, but the continuity of the lymphatics be interrupted, infection does not ascend. (*c*) If the pelvis of the kidney be directly connected with the gut the general infection characteristic of an ascending infection of the kidney does not occur."

Crabtree,[12] on the other hand, argues in favor of the mixed ascending infection, perhaps departing from the lower urinary organs by way of the lymphatics but reaching the general circulation and producing a bacteriemia, then an acute renal congestion, and so ultimately a descending urinary infection of circulatory origin. Such is doubtless the correct interpretation of "urethral chill," for the actual chill is often, perhaps always, preceded (but not followed) by bacteriemia. Crabtree cites, among other evidence, a prostatic whose infection showed first as a bacteriemia and then a bacteriuria. He was later operated upon, died of streptococcus septicemia, and postmortem his kidneys were passed as normal (Fig. 172).

The Irruption of a Neighboring Focus.—Direct extension of an adjacent inflammation into the kidney (*e. g.*, from a retroperitoneal suppuration due to appendicitis) is rare. Its mechanism is sufficiently obvious.

Direct Lymphatic Invasion.—The lymphatic theory of ascending infection from the bladder to the kidney is a good example and perhaps the only proved example of direct lymphatic invasion. It is true that Franke[18] has shown a direct lymphatic communication between the colon and the right kidney and Crabtree revives the opinion of van Calcar and others that the bladder may be infected directly from the rectum, but the evidence in favor of either theory is not entirely clear.

Traumatic Infection.—That the kidney may be infected through operative and other wounds requires no explanation.

Crabtree's Theory of Renal Infection.—After gathering together the known facts concerning renal infections, and testing them both clinically and experimentally, Crabtree has evolved a theory of renal infection that may be paraphrased as follows:

Whether the infection be derived from an inflammation of the lower urinary organs of some other region—whether it be, in the familiar phrase, "ascending" or "descending"—the bacteria usually first reach the kidney in the blood, not in the lymph stream.

Among the bacteria thus reaching the kidney some, notably the pyogenic cocci, more readily produce pus and may be ranked as organisms of high pathogenicity, while others, notably the colon group, produce pus less readily and may be ranked as of low pathogenicity.

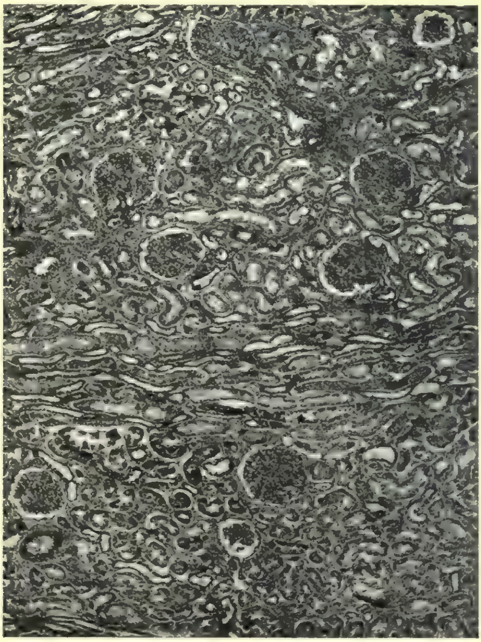

Fig. 172.—Typical microscopic field from the kidney of patient known to have had colon pyelonephritis of hematogenous origin attended by a marked fall in phthalein output and subsequent return to normal function. The kidney is essentially normal. (Photo by L. S. Brown, $\times$ 45.)

All bacteria are transmissible through the kidney without permanent injury to this organ. These bacteria may be recovered from the urine dead (by smear) or alive (by culture). In either event the kidney may suffer only a temporary damage, discernible clinically as a reduction of phenolsulphonephthalein output. But if the patient later comes to autopsy all pathological evidence of this brief infection may have disappeared (as in the case cited). This holds true even for the tubercle bacillus.

On the other hand, if the bacteria do cause an acute renal infection the disposition of this accords roughly at least with the pathogenicity of the infecting organism. The pathogenic cocci infect the glomeruli

themselves. This infection results "in suppuration and the production of focal abscesses and extensive perirenal fat invasion with abscess formation, or a diffuse suppurative pyelonephritis. Cocci appear in the urine late, and usually there is little pus in the urine to indicate the extent of the process, due, no doubt, to the fact that the lesions are of the cortex of the kidney, not of the pelvis and tubules."

The colon group of bacilli act quite differently. They are readily secreted into the tubules, reach the urine early, produce acute lesions of the tubules and pelvis rather than of the glomeruli, and persist "as an infection of the pelvis with recurrent invasions of the kidney tissue from time to time through ascending infection"—from the pelvis of the kidney—"within the kidney. Repeated invasion of renal tissue carried along the tubules possibly, but probably along the intertubular spaces by means of the lymphatics, produces a series of injuries which gradually work toward destruction of the kidney."

This theory explains so many of the known facts that it deserves consideration, although it still awaits confirmation.

Accessory Causes of Infection.—That the normal epithelial cell will doubtless not transmit living bacteria is probable in the light of our present knowledge; that the normal kidney cells are usually able to destroy such bacteria as reach them is equally probable, both in the light of human experience and that of experimentation. Yet so overwhelming a "dose" of bacteria may reach the kidney at a given moment as to overcome its resistance and cause acute inflammation.

Such, indeed, is commonly believed to be the cause of the so-called focal suppurative nephritis. But careful study of such cases commonly shows some accessary cause of infection, and we have so much evidence in favor of chronic unsuspected infection in many of them that one is tempted to say of acute suppuration in the kidney what has often been said of acute Bright's—that it is usually only an exacerbation of a chronic lesion. Although the existence of a preceding chronic infection may be unproved for a given case, it is nevertheless wiser for the physician to assume its existence too often rather than to neglect it altogether.

In adult life, at least, the effect of a massive "dose" of bacteria upon the normal kidney is exemplified by the case of Crabtree, cited above. It causes a temporary congestion, a lowering of functional activity; then the kidney returns to normal—though a microscopic focus of latent Bacillus coli infection may persist in the pelvis. Exceptionally the "dose" of bacteria may be so great that both kidneys are overwhelmed by it and the pyemic kidney results. But unilateral focal suppurative nephritis rarely if ever occurs except in a kidney whose resistance is lowered by some "accessory cause."

The accessory causes of renal infection include any condition, whether mechanical or toxic, that reduces the resistance of one or both kidneys to infection. The names of such influences are of course legion. Only the commoner ones require consideration. These are:

1. Retention (*a*) urethral, and (*b*) ureteral.
2. Trauma.
3. Toxic Influences.
4. Reflex Influences.

Retention.—Retention of urine may result from urethral or from ureteral obstruction. The former is usually due to urethral stricture or to prostatic enlargement (less often to stone, tuberculosis, abscess, tumor, etc.). It results in bilateral retention and infection.

Ureteral obstruction is usually unilateral. It may be due to obstruction within the ureter (*e. g.*, stone, tumor, blood clot, stricture), to angulation of the ureter (*e. g.*, nephroptosis or traction by tumors within the pelvis), or to pressure from without (*e. g.*, by the pregnant uterus) by carcinoma, by appendicular or other abscesses, etc.

The urethral obstructions, inasmuch as they cause vesical as well as renal retention, are readily recognizable; but ureteral retention may be so slight as to cause a retention of urine very small in quantity or intermittent in quality (*e. g.*, nephroptosis). Such retention, though it be so slight or so intermittent as to elude the most careful observation, may nevertheless so congest the kidney as to occasion infection from circulating bacteria that would otherwise do no harm.

For it is by congestion (the congestive reaction to back-pressure in the urinary tract) that retention damages the kidneys.[1] There is also, in the grosser conditions at least, retention of urine (and of bacteria if any such are being excreted by the kidney). But though such retained urine forms an ideal culture medium, yet many renal infections occur at a period when the retention is so slight and clinical evidence of residual urine in the pelvis of the kidney so lacking that we must fall back upon congestion as the actual important factor.

Trauma.—We may include in the traumata that occasion renal infection not only such open wounds as at once introduce bacteria and harrow the soil for their reception; not only the subparietal contusions and lacerations that harrow the soil to await the seed; but also the trauma of slight bruises and wrenches, sufficient to contuse the kidney and yet to evoke no symptoms, as well as that of renal stone which forms at once a source of irritation and a nidus for infection.

Toxic Influences.—Some poisons predispose the kidney to infection more than others. Thus it has not been noted that acute Bright's disease or acute congestion resulting from chemical irritation are likely to be followed by bacterial nephritis. The same may be said of the acute nephritis complicating the exanthemata, excepting only typhoid. Tuberculosis of one kidney often causes toxic nephritis in its fellow, which rarely becomes mildly infected.

But the toxins of the ordinary pyogenic bacteria and of Bacillus typhosus seem quite definitely to predispose the kidney to infection. The last named furnishes a good example. A large minority of typhoid patients develop pyelonephritis, and a large majority of these promptly recover from the renal lesion after the subsidence of their systemic

infection. To invoke a mechanical congestion, such as retention from slight renal mobility, as the cause of this infection is unwarranted; for such congestion would neither occur so frequently nor be relieved so readily. The infection is doubtless occasioned by the congestion resulting from the simultaneous attack of bacterial toxins and the circulating bacteria themselves in what may be termed an overwhelming dose.

Many of the milder bilateral renal infections, especially in infancy, may be due to a similar process, the infecting colon bacillus being derived from an attack of colitis. But the evidence in this connection is not quite so clear; the acute infections of infancy are characteristically unilateral, and therefore due to some predisposing mechanical cause (nephroptosis) in the kidney attacked rather than to toxemia.

But the most striking example of toxic infection is perhaps exhibited in this very connection, for with the acute intense infection of one kidney there is usually a mild infection of its fellow (a catarrhal pyelitis or a bacteriuria).

This can be explained in three ways: either both kidneys are infected primarily by the "dose" of circulating bacteria, the one severely because of its mechanical retention (nephroptosis) and the other mildly, or both are infected primarily and mildly, following which an acute mechanical retention of the one induces acute infection in it; or the acutely infected kidney is first hit, because it is mechanically a *locus minoris resistentiæ*, and the mild infection of its fellow subsequently results from the toxemia and bacteriemia due to this acute nephritis. All these hypotheses are tenable; I rather fancy the last. We see many gross examples of compensatory hypertrophy of a kidney due to grave infection of its fellow—hypertrophy so marked as to cause actual pain. Obviously such hypertrophy results from congestive processes which may very well make the kidney liable to infection.

Reflex Influences.—The renorenal reflex has aroused much discussion. In the sense just mentioned its existence is admitted. Grave disease in one kidney undoubtedly excites hypertrophy of its fellow, and doubtless encourages infection therein. (Yet it is to be noted that such infection remains mild so long as there is no retention in or trauma to this kidney.) But there is no more evidence that pain ensuing from a lesion in one kidney is felt in its fellow than that any other internal sensation should be thus transferred.[17]

The existence of the *prostatorenal reflex* can hardly be doubted; yet urethral chill, its familiar manifestation, never occurs unless the kidney be previously infected or damaged by retention. It is an acute exacerbation in chronically infected kidneys.

Can the Kidneys be Infected without Intervention of Mechanical Accessory Causes?—Yes and no. Acute renal infection, if simply due to overwhelming bacterial invasion of a kidney previously normal, produces the characteristic fatal bilateral "pyemic kidney."

Acute infection of a kidney previously inflamed, or damaged by trauma or retention, produces characteristically unilateral focal suppurative nephritis.

But there remains a third class of cases whose lesions are those of focal suppurative nephritis, but who are not known to have had previous trauma, retention, or infection. Such a lesion is commonly classified as "multiple septic infarcts" of the kidney. In favor of such a classification are two facts:

1. The lesions suggest pyemic infarcts by their wedge shape.
2. They often occur in cases with a recognizable focal (tonsillitis, furunculosis) or catarrhal (colitis) source of infection.

Against this classification[1] the following facts may be urged:

1. Pyemic infarcts are actually bilateral, spherical rather than wedge-shaped, cortical rather than medullary. Focal suppurative nephritis shows quite contrary characteristics. The embolic infarct is actually a mechanical, non-suppurative lesion, and is usually not wedge-shaped. The wedge-shaped septic infarct represents the lymphatic distribution of an acute outbreak in a chronic infection of the kidney pelvis.
2. That the renal lesion is not part of a general pyemia is proved by absence of lesions in other viscera, even in the opposite kidney. Hence it can only be explained on the theory that the affected kidney is a *locus minoris resistentiæ*.
3. The renal lesion of the so-called multiple septic infarcts is precisely that of focal suppurative nephritis.
4. Even though there be no history of precedent infection, nephrectomy for focal suppurative nephritis reveals evidence of chronic pyelitis.

On the whole, therefore, there seems no warrant for separate classification of "septic infarcts." There seems, indeed, to be grave question of their existence. Hence, as a working hypothesis at least, we may lay down the rule that local conditions of trauma, retention, and antecedent infection are the determining factors in the etiology of acute renal suppuration.

The bacteria that actually cause acute suppurative nephritis may be resident in the kidney (chronic pyelonephritis) or may reach it by ascending or descending invasion. Our own impression is that acute suppuration is but the lighting up of a chronic pyelonephritis in the majority of cases, though our present knowledge does not warrant any statistical discussion of this point.

But the nature of chronic renal infections is far more obscure. We know, on the one hand, that bacteriuria discernible only by culture may persist for years after an acute infection in infancy. On the other hand, we have such observations as Albeck's[1]. He found in the early months of pregnancy, 8 cases of vesical and 5 cases of renal bacteriemia, while in the later months he found 0 cases of vesical and 8 cases of renal bacteriemia.

If we are to assume that the normal kidney usually destroys such bacteria as reach it from the circulation, and that accessory causes of infection are indeed the occasions of chronic infection, these accessory causes must explain the reason why infections occur in childhood, why

women are more subject to them than men, and why infancy and pregnancy usually constitute the periods of maximum danger for women.

What, for example, is the mechanical cause of acute renal infection occurring in the right kidney during pregnancy? No one dissents from the theory that this is due to the pressure of the gravid uterus upon the right ureter, *i. e.*, to retention in the right kidney. But what then is the mechanical cause of the acute renal infections of little girls? Doubtless it is the shape of the lumbar recess.

Volkow and Delitzen long ago showed that the shallowness of the lumbar recess in women as compared with men, and on the right side as compared with the left, is the occasion of the movable kidney. Cabot and Brown have developed the same theory to account for renal infection. They believe that the so-called spontaneous bacterial infection of the kidneys occurs in the movable kidney. They have thus been able to cure renal infection (personal communication) by orthopedic exercises calculated to enlarge the expansion of the lower chest and the costovertebral angles. In 1 case they were able even to predict an acute renal infection on account of the patient's bad position, and this same case was cured by these exercises. Thus there is good reason to believe that the mechanical cause of acute infections in the right kidney is the mobility of this kidney, occasioning either slight torsion of the vascular pedicle or slight retention by the kinking of the ureter. That such infections should show themselves most commonly in women and on the right side is thus explained. That they occur so frequently in infancy is perhaps due as much to the great susceptibility of children to all types of infection as to the obvious fact that a movable kidney is more likely to be infected early than late. That renal mobility becomes grossly recognizable only after adolescence, in the great majority of instances, has no bearing upon this theory, for such mobility is very gross compared to the slight mobility required to occasion renal infection.

But if retention due to renal mobility is the cause of many acute renal infections it does not so satisfactorily explain the tendency for chronic infection to be bilateral and for acute infection on one side to be accompanied by chronic infection upon the other. This is perhaps due to toxemia from the kidney first infected.

Thus the mechanical causes of renal infection must be considered almost more important than the bacteria themselves. Though, as has already been stated, not only do bacteria frequently circulate in the blood as the result of various focal and catarrhal infections, but they also are frequently present, quite unsuspected, in the pelvis of the kidney itself. But so long as there is no trauma, no retention, no kinking of the ureter, and no stone the circulating bacteria have no effect upon the kidney; the bacteria in the urine produce no appreciable lesion, but let any one of these accessory causes make itself felt and the kidney soon becomes infected, either from the bacteria which its

pelvis already contains, or from those in the blood stream. In short, the accessory causes of infection, notably the manifold forms of retention, whether urethral or ureteral, are the active causes of infection and constitute the main elements of the infection that can be attacked by the urologist.

The opposite theory, viz., that the shortness of the female urethra and the proximity of the infected vagina account for the relative frequency of renal infections among women explains vesical but not renal infection, for no reason is alleged to explain the ascent of infection along the ureters save retention in those organs. Thus Brewer[6] failed to produce renal infection in dogs by injection of various bacteria into the bladder even after contusion of the kidney, producing aseptic infarcts or leaving foreign bodies in the kidney pelvis.

PATHOLOGY OF RENAL INFECTIONS.

The lesions of renal infection must be described piecemeal, though they never occur piecemeal. We must describe the lesions of the parenchyma apart from those of the pelvis, though they do not occur apart. No suppurative nephritis (except the pyemic kidney) but is accompanied by pyelitis; no pyelitis without nephritis. Hence in describing the clinical features of renal infections the word pyelitis is replaced by pyelonephritis. Moreover, the various lesions described below may follow one another under appropriate circumstances in a given case.

The following classification will serve our purpose:

1. Acute suppuration of the kidney.
    - (*a*) The pyemic kidney.
    - (*b*) Focal suppurative nephritis.
2. Acute pyelitis.
3. Chronic pyelonephritis.
4. Pyonephrosis.
5. Infected hydronephrosis.
6. Perinephritis.
    - (*a*) Fibrolipomatous.
    - (*b*) Suppurative.
7. Rare inflammatory conditions of the renal pelvis.
    - (*a*) Pyelitis granulosa.
    - (*b*) Malakoplakia.
    - (*c*) Pyelitis cystica.
    - (*d*) Leukoplakia.
    - (*e*) Incrustation.

The Pyemic Kidney.—The pyemic kidney is but part of a general pyemia. It presents no noteworthy symptoms during life, but post-mortem both kidneys and the other viscera are found dotted with abscesses. Thus the condition has no clinical interest. Death comes so soon that it is the rule to find the suppuration not far advanced. The

kidneys are but little enlarged. The surface is dotted with small points of suppuration. These are generally distributed through the parenchyma, but chiefly in the cortex (Plate V). The wedge-shaped lesions so characteristic of focal suppuration are not seen.

Microscopically the kidney shows the familiar lesions of suppuration and round-cell infiltration with destruction of the adjacent parenchyma and congestion of the whole organ. This is the only suppurating lesion of the kidney parenchyma without corresponding lesions in the kidney pelvis.

FIG. 173.—Subacute staphylococcus infection of the kidney showing multiple small abscesses of the renal tissue and much perinephritis. There are minute abscesses in the perinephric fat. (Blake.)

Focal Suppurative Nephritis.—This lesion, which has been made familiar in America by the writings of Brewer under the title of "Septic Infarcts of the Kidney,"[7] differs from the actual septic infarcts of pyemia in several characteristics alluded to above. It is unilateral: it is characterized by wedge-shaped lesions rather than the multiple discrete abscesses of pyemia; it is associated with changes in the kidney pelvis; it is certainly in many instances, and possibly in all, excited by mechanical disturbances in the kidney itself.

The kidney is usually enlarged. Upon its surface small abscesses (Figs. 173 and 174) may perhaps be seen beneath the capsule; but

PLATE V

Staphylococcus Septicemia. Multiple Abscesses of the Kidney.
(MacCallum.)

the more characteristic lesions are irregularly distributed patches distinctly projecting underneath the capsule, darker in color than the surrounding parenchyma, and perhaps dotted by pale areas of suppuration. On section these irregular areas are found to be the bases of pyramidal patches of intense congestive suppuration and necrosis which have their apices at or near the pelvis of the kidney.

The microscope reveals intense congestion of the kidney parenchyma in general, while in the pyramidal areas of more acute infection the parenchyma is destroyed by round-cell infiltration and necrosis. At the edges of the suppurating lesions the extension of the round-cell infiltration between the tubules, is very plainly visible.

Fig. 174

At a more advanced stage these pyramids of suppuration break dowu to form ovoidal abscesses (Figs. 175, 176, 177 and 178), and these in turn may coalesce or rupture either into the pelvis of the kidney or into the perinephritic tissue, which latter is densely adherent, sclerotic, or suppurating (Fig. 179). The pelvis is inflamed. The opposite kidney is usually the seat of mild chronic pyelonephritis.

Acute Pyelitis.—Acute pyelitis does not occur without suppurative nephritis any more than does acute nephritis without pyelitis, but the

lesions in the pelvis may predominate. Such cases do not have grave symptoms and do not require operation, therefore a pathological speci-

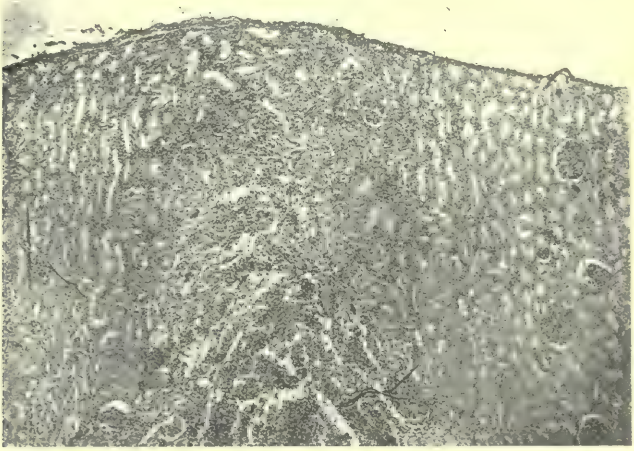

Fig. 175.—Upper edge of small cortical abscess 2 mm. below the capsule. Infecting agent pure Staphylococcus albus.

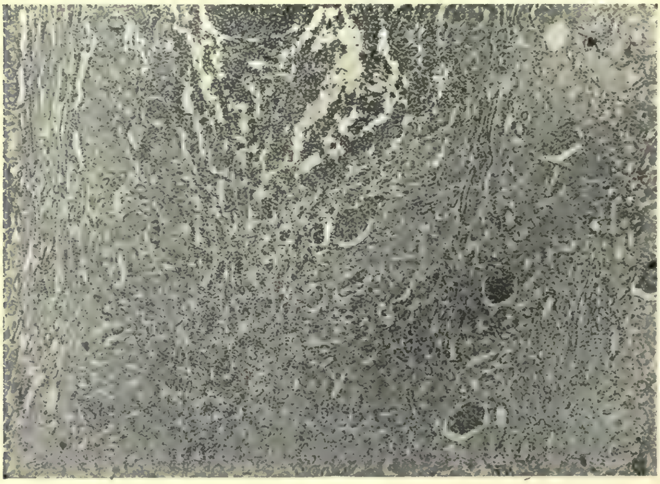

Fig. 176.—Lower edge of abscess shown in Fig. 175. Note line of tubules filled with pus extending down into the kidney. There is some pus-cell infiltration of the interstitial tissue. (Photo by L. S. Brown, × 40.)

men is rarely seen. I have seen one such removed by mistake for tuberculosis. The parenchyma of the kidney looked grossly quite normal, microscopically it showed here and there slight necrosis and

round-cell infiltration; but the kidney pelvis was a bright scarlet throughout, its walls thickened, and the cellular tissue about them slightly edematous.

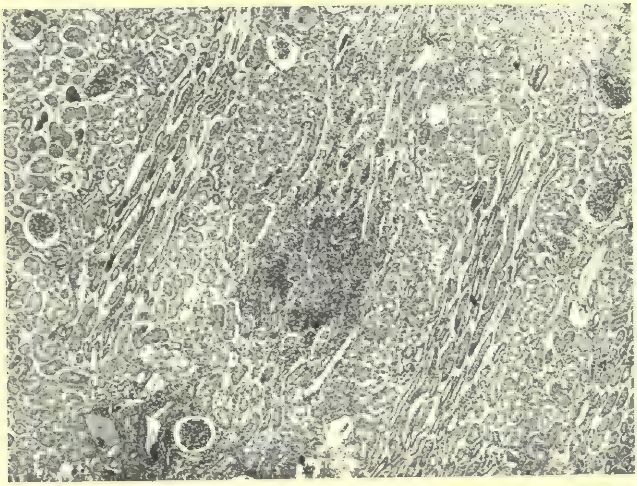

FIG. 177.—Small abscess found immediately below abscess shown in Figs. 175 and 176 in a column of Bertini.

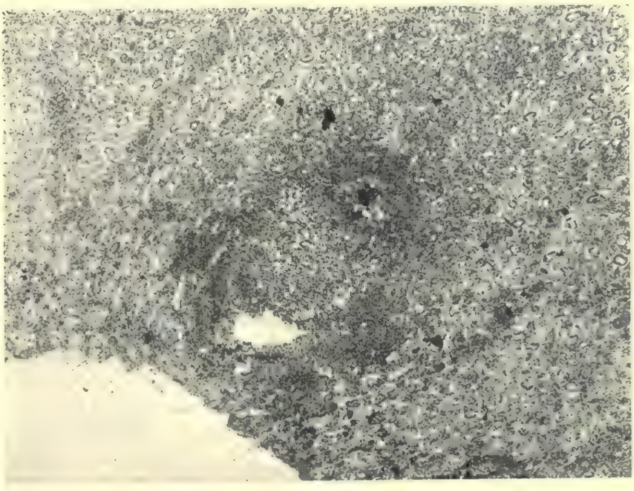

FIG. 178.—Abscess situated in the straight tubules of the tip of the papilla. (Photo by L. S. Brown, × 40.)

Chronic Pyelonephritis.—The lesions in the kidney parenchyma vary from such acute ones as peritubular round-cell infiltration, with here and there a collection of round cells threatening suppuration or

actually breaking down into pus, to more chronic lesions resulting from this infiltration. The round cells are finally organized into scar tissue, many tubules are destroyed and replaced by scar, the remaining ones are distorted and their epithelium more or less flattened and destroyed. The gross aspect of the kidney parenchyma itself is not very different from that of chronic nephritis. The capsule is adherent and the markings lost. There may be cysts and areas of suppuration here and there, but these are rare. But the parenchyma is thinned, shows gross scars of old suppuration, and the calyces are much dilated.

The pelvis is usually somewhat dilated, its walls thickened by inflammatory exudate or scar tissue, and its epithelium flattened or ulcerated.

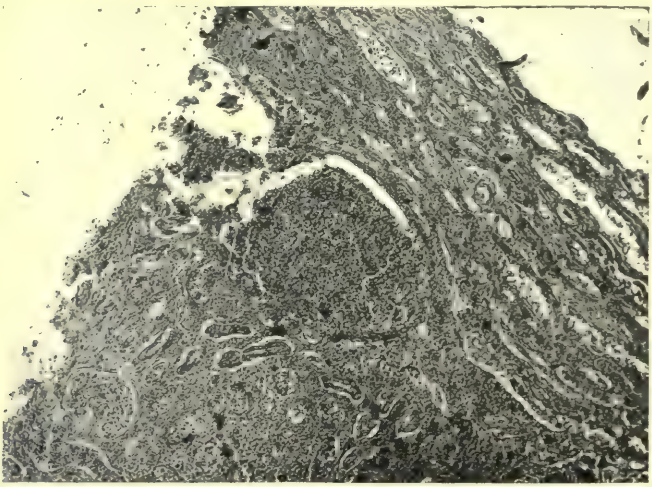

FIG. 179.—One of a small cluster of cortical abscesses which seem to take origin from glomeruli. (Photo by L. S. Brown, × 70.)

The perinephritic tissue in a mild case of chronic renal infection is merely somewhat thickened and adherent to the fibrous capsule. The fat in the immediate neighborhood of the kidney is edematous or adherent. But if the suppuration has been severe or prolonged within the kidney, the perinephritic tissue in its vicinity is transformed into a mass of scar and densely adherent fat—the typical fibrolipomatous perinephritis.

Phosphatic calculi form in the kidney pelvis as the result of infection with the urea-splitting bacteria.

Pyonephrosis.—Pyonephrosis is that condition in which the kidney substance is reduced to a sclerotic shell cupping a dilated pelvis of the kidney full of pus (Fig. 180). The more severe grades of pyelonephritis merge insensibly into pyonephrosis. Indeed, all chronic cases of pyelonephritis show a certain amount of dilatation of the pelvis and doubtless

some little retention of infected urine, but classical pyonephrosis is very different from this. Its pus is thick and creamy, and one is surprised to find that it contains any urea at all (though this may rise as high as 5 grams to the liter). While pyonephrosis may be due to ureteral occlusion it is quite often seen with a ureter that seems perfectly patent and drools a worm-like, thick pus into the bladder; the ureter catheter passes readily to the pelvis of the kidney, but the pus is too thick to issue from this in any quantity. The kidney may be greatly enlarged. It is usually found embedded in a densely adherent mass of fibrolipomatous perinephritic tissue. This surrounds the vascular pedicle, the pelvis, and ureter as well as the kidney itself. This envelope is so adherent that the kidney can often only be released from it by stripping off the fibrous capsule.

Fig. 180.—Pyonephrotic kidney, showing rounded lobulations distended with pus. Evidence of some perinephric inflammation is seen in tabs of adherent fibrous tissue and thickening of the peri-ureteral tissue.

When thus exposed the kidney presents a lobulated appearance, suggestive of congenital lobulation. But palpation reveals that the seeming lobuli are the thin walls of cavities within. Section of the kidney gives exit to its thick pus and exposes a large central cavity (the dilated pelvis), from which radiate a group of secondary cavities (the dilated calyces). These extend to the very surface of the kidney and are separated from its capsule and from each other by relatively

thin septa of scarred parenchyma. In old cases the parenchyma is actually replaced by fibrolipomatous tissue continuous with the perinephritic fibrolipoma.

The dilatation may be chiefly within the kidney (in which event it is attributed to a predominating suppuration within the kidney) or chiefly in the pelvis (attributed to a predominating retention).

The pelvis is dilated, its walls greatly thickened by scar, and still further by the adherent fibrolipomatosis.

The ureter, as usual, partakes of the pelvic changes.

The microscope reveals scarcely a trace of renal parenchyma. Only a few deformed dilated tubules and glomeruli are left amid a mass of scar, suppuration, and fatty degeneration.

Infected Hydronephrosis.—When the kidney is primarily distended by obstruction of the ureter and only secondarily infected, the resulting lesion is more likely to be an infected hydronephrosis. (Indeed, almost all hydronephroses are infected.) The general character of the distended kidney is that of hydronephrosis as described elsewhere. The remaining kidney parenchyma is in large part sclerotic, the contents of the sac are watery with low urea content, but clouded with pus.

Perinephritis.—The lesions in the perinephritic cellular tissue excited by suppuration within the kidney or less often by suppuration in some other adjacent organ assume one or two forms, depending upon whether the inflammation is purely protective and not accompanied by actual suppuration, or whether the bacteria invade the perinephritic tissue in sufficient number to cause abscess formation.

Although the Bacillus coli predominates as the cause of infections within the kidney, the pyogenic cocci predominate in perinephritic suppuration. Thus Miller[29] found staphylococci in 12 cases, streptococci in 2, streptococci and pneumococci in 1, Bacillus coli in 6, while 2 were sterile.

Fibrolipomatous Perinephritis.—The protective type of perinephritis is seen to a greater or lesser degree in connection with every chronic suppuration within the kidney or its pelvis; for it consists of nothing more than a round-cell infiltration and subsequent sclerosis, whereby the connective tissue with the fat in its meshes becomes more densely adherent to the kidney over its surface. But this process if long continued leads to cicatrization with fatty degeneration, whereby the kidney envelope is changed into a dense mass of scar, yellow with contained fat. This fat is not the normal soft, lobular, perirenal fat, but a hard mass held firmly in the meshes of scar tissue.

Suppurative Perinephritis.—Suppurative perinephritis is usually due to a rupture of an abscess in the kidney parenchyma through the fibrous kidney capsule. The suppuration may be confined to the adjacent region or may spread throughout the perinephritic fat and escape downward into the iliac region, following the course of the ureter.

Retroperitoneal abscess in the loin originating in an organ other than

the kidney is usually para- rather than perinephritic, *i. e.*, it occupies the region outside the perirenal fatty-fascial envelope. Such abscesses are also classed as subdiaphragmatic.

Thus Braasch[5] reports in 101 cases: 34 (probably 38) paranephritic, 63 perinephritic. The cause of these 63 abscesses was pyonephrosis (12), focal suppuration (12), stone (11), renal tuberculosis (10), rupture of kidney (4), and unknown (18 cases).

Rare Inflammatory Conditions of the Renal Pelvis.—Certain rare complications of chronic pyelitis may be grouped together here. The connection of bacterial inflammation with the first two mentioned has not been proven.

Pyelitis Granulosa.[26]—Pyelitis granulosa (pyelitis follicularis) is a lymphoid infiltration of the kidney pelvis. The lymphoid tissue occurs as little nodules, the size of a millet seed, dotting the mucous membrane. General pyelitis, papillitis, and bacterial nephritis are inconstant epiphenomena. The lymphoid follicles may also occur in the ureter and the bladder trigone.

The follicles consist of an aggregation of lymphoid cells in a connective-tissue reticulum, showing a tendency to capsule formation. They are very vascular. The smaller ones are covered with epithelium, the larger ones may be ulcerated. They sometimes are incrusted, sometimes show fatty degeneration.

They may produce symptoms, notably pyuria and hematuria, but are more often found postmortem. They are never found in children, and hence are believed to be of inflammatory origin. Baetzner[42] suggests that they may be due to typhoid infection. Similar lymphoid aggregations are occasionally found in tuberculous pyelitis.

Malakoplakia.[27]—This pathological condition is usually symptomless. It affects parenchyma, pelvis, ureter and bladder and is commonest in women. Its etiology is not known. It consists in grayish or yellowish nodules made up of large cells (20μ in diameter) containing peculiar cell inclusions (Michaelis and Gutmann bodies), leukocytes and often Bacillus coli.

Pyelitis Cystica.—This condition is similar to but much rarer than cystitis cystica.

Leukoplakia[2].—Metaplasia of the epithelium of the renal pelvis into cells of the squamous type is very rare. It results from some form of chronic irritation and is usually due to stone or tuberculosis. The mucosa presents irregular areas of thickened epithelium, white upon the surface. It gives no symptoms unless renal colic results from plugging of the ureter by detached epithelial masses.

Calculous Incrustation.[9]—Incrustations form upon any ulcerated surface of the urinary tract, as the result of infection with urea-splitting microbes. Incrustations of the renal pelvis and papillæ rare are. They are most often found associated with tuberculosis.

THE CLINICAL PICTURE OF RENAL INFECTION.

The clinical picture of the various lesions described in the preceding chapter is confused not only by the lack of correspondence between lesion and symptom, but also by the complexity of the lesions themselves. Thus, on the one hand, a pyuria without subjective symptoms may be the only evidence of such widely differing lesions as chronic pyelonephritis and pyonephrosis; while, on the other hand, the lesions of pelvis, parenchyma and perinephritic tissue mingle in various degrees of intensity to produce a clinical picture in which we can often only distinguish the predominant lesion.

In the interest of lucidity it is therefore wise to premise our description of the clinical picture of renal infection with a brief commentary on the significance of the chief symptoms of renal infection.

What the Symptoms Signify.—**Bacteriuria and Pyuria.**—The presence in the urine of bacteria distinguishable only by culture, and unaccompanied by pus, signifies the presence of a lesion so slight that we can give it no name more specific than that of latent infection. When the bacteria are so plentiful as to cloud the urine, there is likely to be a general catarrh of some portion of the urinary tract. If in the kidney pelvis, it is likely to be a chronic mild pyelonephritis.

Pus in a larger amount, if from the pelvis of the kidney, is likely to vary in quantity, even to the extent of being discharged in great quantity from time to time. Such pus if allowed to settle in the bottom of a glass forms a muddy, greenish sediment, flat upon the surface, adherent to the glass when decanted. Pus of this character signifies retention. It may be derived from a bladder diverticulum, but almost invariably comes from the dilated kidney pelvis. It suggests grave pyelonephritis or pyonephrosis.

Pus and bacteria are never absent from the urine excreted by the infected kidney, exception made for perinephritis and about 5 per cent. of cases of focal suppurative nephritis. These are so hyperacute that they produce symptoms due to suppuration within the parenchyma without discharging any appreciable pus into the renal pelvis.

It seems scarcely necessary to repeat that pus does not account for albuminuria; red blood cells do.

Albumin and Casts.—Every infection of the renal pelvis is accompanied by sufficient inflammation of the parenchyma to discharge at least a trace of albumin with the urine. This may be so little as to be discovered only by the most delicate laboratory methods. The percentage of albumin by no means tallies with the results of urea and phenolsulphonephthalein estimation. These latter are far more accurate indices of the renal function.

Casts are almost as notable for their absence in renal infections as they are constant in non-bacterial nephritis. Large numbers of casts are suggestive of toxic nephritis. Absence of casts in no way modifies the diagnosis of bacterial nephritis in any of its forms. This fact is

best illustrated in the familiar findings in unilateral renal tuberculosis, namely, the tuberculous kidney discharges pus and albumin but no casts; the opposite kidney, the seat of toxic nephritis, delivers albumin and casts, but no pus.

Urea and Phenolsulphonephthalein.—These are the essential tests of renal function. Their value requires no further discussion here.

Blood.—Gross hematuria is a rare symptom of renal infection. Apart from stone and tuberculosis it suggests acute nephritis or pyelitis granulosa. Microscopic hemorrhage is common enough. It suggests acute nephritis or ulceration of the pelvis.

Pain and Sensitiveness in the Loin.—Active tension of the renal capsule or pelvis excites tenderness in the loin. This may or may not excite spontaneous pain.

Such tenderness is encountered in renal retention, in focal suppuration, and often enough in the hypertrophied kidney opposite to an infected kidney. Chronic retention may leave the kidney large but not tender.

Actual pain in the loin is but an accentuation of tenderness. Like the latter it may occur either in the diseased kidney or in its hypertrophied fellow.

The characteristic pain of renal tension is felt in the loin, usually as far back as the costovertebral angle; or anteriorly in the region of the gall-bladder (in the corresponding region on the left side) or as low down as the appendiceal region. If severe and high up in the abdomen it radiates across the abdomen toward the umbilicus. If low it may radiate to the pubis and testis or down the thigh.

Frequent and Painful Urination.—Distention of the renal capsule does not cause frequent and painful urination. Distention of the pelvis (or the irritation due to stone or tuberculosis therein) often excites no pain whatever in the loin, but a referred sensitiveness of the bladder, expressed by frequent and painful urination, quite comparable to the irritation so characteristic of cystitis. It is not known whether these referred symptoms can actually occur in the absence of some inflammation in the lower ureter. Certainly frequent and painful urination is usually a sign of inflammation about the bladder orifices, ureteral or urethral. Yet it is occasionally proven by operation to be due to an irritation (*e. g.*, stone) confined to the pelvis of the kidney.

Toxic Symptoms.—The toxemia of renal infection may develop in one of five types:

High blood-pressure.
Rheumatism.
Cerebral symptoms.
Digestive symptoms.
Hiccough.

High Blood-pressure.—High blood-pressure is by no means so commonly associated with grave surgical disease of the kidneys as one would expect. It appears to depend upon the developments of lesions

similar to those of chronic Bright's disease. It is, in other words, a frequent accompaniment of renal infection, but by no means a constant evidence of this.

Rheumatism.—(Using the word crudely to cover toxic arthritis and pains in general) is rarely due to renal infection.

Cerebral Symptoms.—These form part of the picture of a grave urinary toxemia. Unless actually moribund, the patient is usually quite sane the greater part of the time, and is even able to deceive his family into believing that he is entirely rational. Active delirium is especially common at night, but this type of mental aberration is so naturally associated with general toxemia as scarcely to be worthy of mention. On the other hand, certain cases show marked mental aberration without any other sign of renal infection. Such a condition is especially likely to result from pyonephrosis. Such individuals may show mental symptoms so marked and other evidences of septicemia so slight, that the surgeon hesitates to operate, but it is in these very cases that the most brilliant results from nephrectomy for pyonephrosis are obtained.

Digestive Symptoms.—Digestive symptoms are, on the other hand, very characteristic and are constantly met with in all cases of grave renal infection. The patient is usually constipated (though there may be a septic diarrhea), the skin sallow and flabby, there may be more or less edema, and fever if there is sepsis (as described in the following section). But the striking characteristic of urinary toxemia is what the French have termed "buccal dysphagia," *i. e.*, unwillingness to swallow because of dryness of mouth and throat. When this condition is marked the tongue is utterly parched and dry; it is often brilliantly red, though it may be covered with a brown or white coat. The importance of this sign is that the fluctuations in toxemia from day to day are often better expressed by the condition of the tongue than by anything else. A thoroughly dry tongue is a most alarming symptom, no matter how encouraging other signs may be. On the other hand, the reappearance of moisture and a softness of the tongue are the first hopeful signs as the patient begins to improve.

Hiccough.—Hiccough is well known to be a sign of urinary toxemia. It is a grave sign, but, contrary to the prevailing opinion, a patient may hiccough for days and yet recover.

Septic Symptoms.—The clinical picture of renal septicemia is renal toxemia, plus fever. Septic absorption from the kidneys usually differs not at all from other types of septicemia. So far as I know the typical dry tongue always means renal insufficiency. It is to be remembered, however, that this sign may be due to renal insufficiency from Bright's disease or from the renal toxemia due to a septic infection in other parts of the body. The mere presence of buccal dysphagia does not indicate that the infection is primary in the kidneys.

Urethral Chill.—Urethral chill is a form of urinary septicemia. Urethral chill does not occur unless there is renal infection or retention, and, although the chill is excited by the passage of the urethral instru-

ments, it is known to be associated with a bacteriemia, and an estimation of the fall of renal function immediately thereafter will show the renal character of the lesion. The classical urethral chill is a sudden severe chill with temperature rising to 104° or more, immediately following the first urination subsequent to the passage of a urethral instrument. Then in a few hours the temperature falls to normal and the chill is over. But careful observation will reveal that this classical chill is subject to a great variation—in its severity, in its time of appearance, its intensity and especially in its subsequent history. It usually tails off with a few irregular elevations of temperature during the following days, and not infrequently is the starting-point of a definite renal septicemia. The cause of urethral chill appears to be the liberation into the circulation of bacteria from the prostatic gland abraded or contused by the passage of instruments.

Symptoms of the Pathological Types of Renal Infection.—In the preceding paragraphs the symptoms of renal infection have been described in detail. We may now group them first in their pathological and then in their clinical types. It is to be remembered, however, that with variations in intensity of infection and retention and trauma a given lesion may change its character to the extent of covering the whole range of pathological lesions. Clinically and pathologically, renal infections are therefore one in essence but protean in manifestations.

The symptoms of pyelitis granulosa, leukoplakia, etc., have been described with sufficient accuracy in the preceding paragraphs. We may now confine ourselves to the clinical picture of acute renal infection (including acute pyelonephritis, pyonephrosis and focal suppuration), chronic pyelonephritis, pyonephrosis and perinephritis.

Acute Renal Infection.—The attempt to differentiate between acute pyelitis, acute pyelonephritis, and focal suppurative nephritis is warranted neither by the lesions themselves nor by the clinical course of the infection. There is no acute pyelitis without nephritis. Acute pyelonephritis is but a mild type of focal suppurative nephritis.

For clinical purposes we may describe mild cases, severe cases, and fulminating cases.

Mild cases of acute renal infection usually exhibit only a brief rise of temperature with a discharge of pus, bacteria and albumin into the urine. The accompanying leukocytosis shows the fever to be due to suppuration, but the patient complains of little or no pain in the loin. The urinary pus therefore reveals the true situation and palpation reveals a tenderness or possibly an enlargement of the affected kidney. Such cases sometimes have a misleading reflex irritation of the bladder. Under proper treatment such an acute renal infection usually subsides very rapidly.

Severe cases of acute renal infection are characterized by a considerable rise of temperature. The fever is usually extremely irregular and may be ushered in or interrupted by chills. Pain and aching in the

loin may be very severe or entirely absent; but tenderness may always be elicited by ballottement. There is not likely to be any bladder irritability; indeed, reflex congestion of the opposite kidney plays a part in greatly reducing the total volume of urine. The more acute the inflammation, the less likely is there to be any pus in the urine. The course of this infection depends almost exclusively upon its treatment. But even under the best of care it is likely to follow an irregular course with many relapses, and often, though the primary mechanical cause of infection (*e. g.*, pregnancy) be removed, the secondary causes of retention in the form of urethral kinks or pelvic dilatation may persist and occasion subsequent acute attacks.

Fulminating cases of acute renal infection are characterized by repeated chills and extremely high temperature, with almost complete absence of any symptoms suggesting the location of the infection in the urinary tract. The local pain, if not absent altogether, is often so slight as to be quite misleading, and the unsuspecting surgeon usually operates in a vain search for acute appendicitis, cholecystitis, or some other intraperitoneal inflammation. Urinalysis suggests nothing in a very large minority of cases. Even when pus is specifically looked for, it is not always found. The microscope always reveals albumin and red blood cells, but these establish no diagnosis. Diagnosis is made by eliciting tenderness in the loin and by ureter catheterization which reveals a marked inhibition or perhaps total suppuration of the function of the infected kidney.

These are the patients who are so gravely infected that they require immediate nephrectomy. If performed before the sepsis has gone on to the point of overwhelming the opposite kidney this operation is almost universally successful.

Chronic Pyelonephritis.—By chronic pyelonephritis we understand that condition in which there is infection of the kidney without marked retention and dilatation as in pyonephrosis and without the acute febrile conditions just described. In intensity the infection varies from a microscopic bacteriuria to a definite pyuria, *i. e.*, from an almost microscopic lesion (Fig. 182) to an active, general suppuration of the kidney pelvis (Figs. 183, 184 and 185) and adjacent parenchyma; from a lesion of practically no importance, excepting in its threat of an acute or chronic exacerbation due to retention or trauma, to an active infection destructive of the renal parenchyma and ultimately of the patient's life. The infection is usually bilateral, it may be the result or the cause of stone formation.

The symptoms of chronic pyelonephritis are:

1. Pus, albumin, and bacteria in the urine.

2. Diminished renal efficiency, as measured by phenolsulphonephthalein, together with dilatation of the renal pelvis up to 15 or 20 c.c. capacity.

3. Beyond these urinary signs there may be no symptoms; but certain cases are characterized by reflex bladder symptoms, by the

occurrence of acute renal infection from time to time, or ultimately by symptoms of renal toxemia or septicemia that indicate extensive destruction of the renal parenchyma.

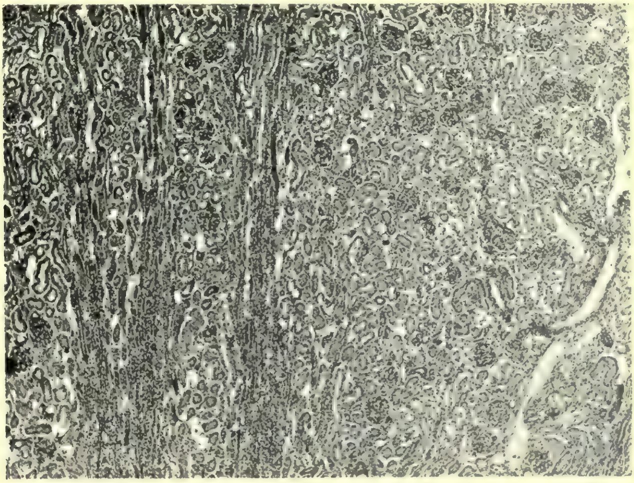

FIG. 181.—Typical area from the kidney of a child with chronic pyelonephritis which now presents the picture of a pure pyelitis. The kidney tissue is normal throughout. (Photo by L. S. Brown, × 45.)

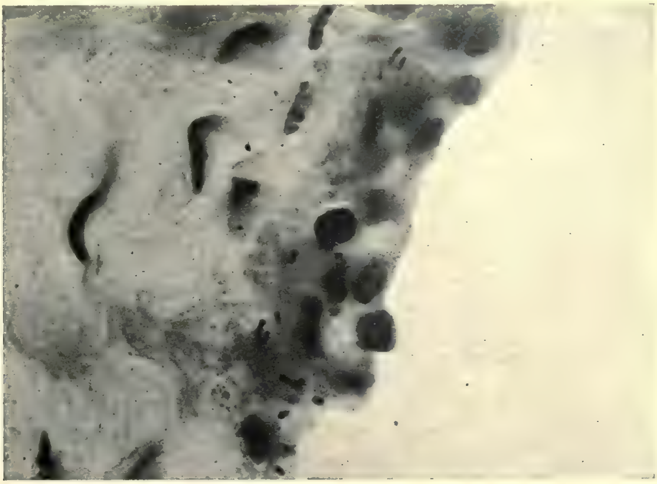

FIG. 182.—Microphotograph portion of pelvis (same case as Fig. 181), showing slight thickening of mucosa without submucous change and large numbers of colon bacilli growing in the mucosa. (Photo by L. S. Brown, × 1500.)

The course of chronic pyelonephritis depends in large measure upon drainage. If the ureter drains the pelvis of the kidney adequately the

chronic infection is likely to amount to little more than a bacteriuria. Such an inflammation if uninterrupted by acute attacks of pyeloneph-

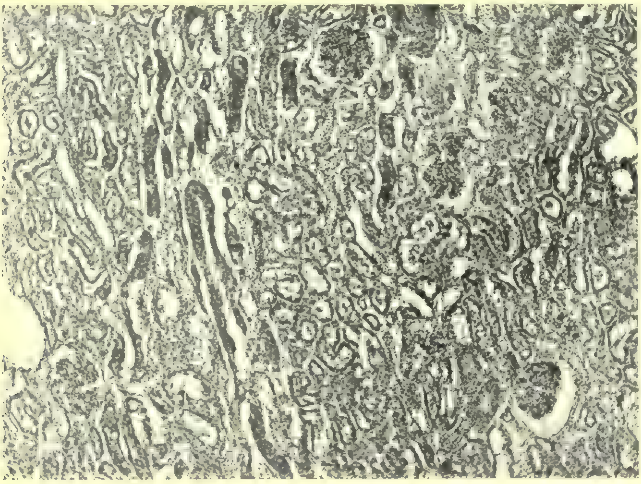

Fig. 183.—Typical appearance of the kidney of a chronic colon bacillus pyonephrosis, the result of a pyelitis of infancy. Note moderate lymphocytic infiltration and extensive damage to convoluted tubules. The glomeruli are unchanged. (Photo by L. S. Brown, × 45.)

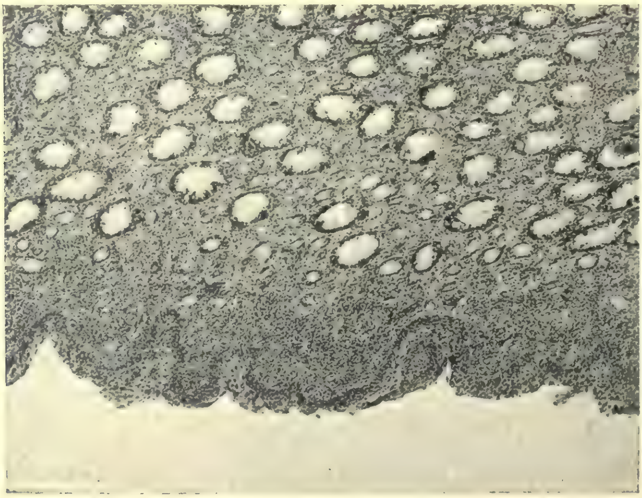

Fig. 184.—Pelvis of same case as in Fig. 183, showing thickened mucosa and submucosa, increase in interstitial tissue and dilated collecting tubules of the pyramid. The submucosa is extensively infiltrated with lymphocytes and an occasional pus cell. Colon bacilli are numerous in the mucosa, rare in the remainder of the kidney. (Photo by L. S. Brown, × 45.)

ritis will be found to impair the renal function very little and to run a long and symptomless course.

As extreme examples of longevity the following cases may be cited:

CASE I.—Male, aged forty years. January 15, 1869, consulted my father with a history of syphilis and of retention of urine during the preceding six months. In spite of various treatments, both for the syphilis and the retention, the latter soon became complete. He was under observation from time to time by my father until I first saw him thirty years later, in 1899. Three years before that time the record shows that he had discharged large quantities of pus in the urine. He had a bladder paralysis due to syphilitic spastic paraplegia. The urine was acid, contained little pus, many Gram-negative bacilli; specific gravity, 1013; albumin, a marked trace by the nitric acid test. Hyaline and granular casts were occasionally found. His rather active

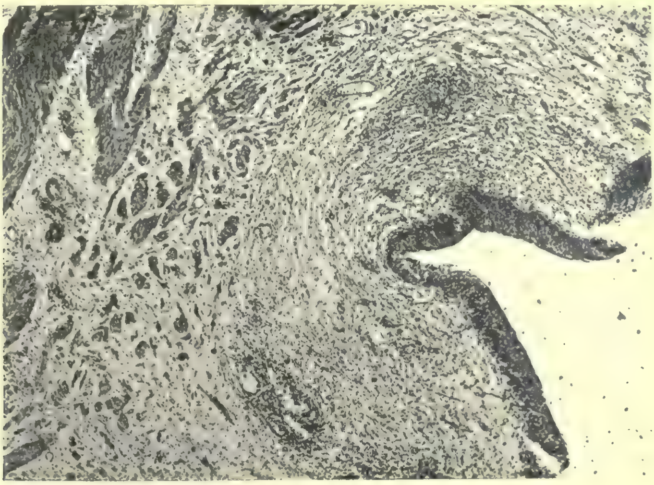

FIG. 185.—Section of ureter from case shown in Figs. 183 and 184 showing thickened mucosa and submucosa with two collections of cells in the submucosa. There are few pus cells in the submucosa. Bacteria along with pus-cells are found in the mucosa. (Photo by L. S. Brown.)

infection which had proven rebellious to all previous treatment was readily controlled by small amounts of hexamethylenamin. Of this he could rarely take more than two 5-grain tablets a day without exciting intense bladder irritation, but on these days the urine became almost free from pus; he gave up washing his bladder, and for the last ten years of his life depended solely upon this internal medication and the catheter. Under this combination the urine from time to time would look absolutely sparkling. In May, 1910, he died after a few days of uremia. The infection of his urinary tract had lasted for forty years, and he was eighty-one years of age.

CASE II.—Female, aged fifty-seven years, mother of five children, was first seen in July, 1887. She had long been under treatment for a

symptomless pyuria. The urine contained a very marked trace of albumin, hyaline casts, pus and epithelia (both from the bladder and from the pelvis of the kidney); specific gravity, 1018; reaction acid. She had several hemorrhages, and repeated urinalysis (on an average of one a month) during the ensuing years always showed a considerable amount of albumin and pus, but rarely casts. The highest albumin recorded is 3 per cent. by volume. In 1901 Sondern found 0.7 per cent. albumin by weight, no tubercle bacilli, pus, blood, hyaline and epithelial casts; urea, 0.9 per cent.

The series of 65 urinalyses, made between the years 1889 and 1899, showed an average of specific gravity, 1015, a maximum of 1022, and a minimum of 1010.

In January, 1902, she no longer had hemorrhages, but from time to time showed glycosuria. In 1905 she occasionally had slight uremic attacks, but was never seriously ill, and except for an occasional slight irritability of the bladder, remained in singularly good health until, in 1911, a carcinoma appeared in the upper abdomen. Of this she died in the summer of 1913, at the age of eighty-three years, the renal infection having lasted for over a quarter of a century.

Case III.—Male, aged forty-eight years, consulted my father for the treatment of spermatocele in 1879. He gave a history that ten years previously a physician had advised him that his kidneys were so gravely diseased that he would have to give up work and rest absolutely in order to save his life. After following this system for a few months he elected to die in harness. He returned to work and had enjoyed excellent health ever after. Nevertheless, occasional urinalyses showed large quantities of pus, a few blood corpuscles, and some albumin. Such analyses, made in March, 1874, and in May, 1875, are in my possession. The one showed a specific gravity of 1013, the other 1016.

In 1879 my father's first analysis showed a moderate amount of pus; a few blood cells; a nitric acid ring of albumin; no casts; no sugar; no crystals; specific gravity, 1012. Repeated urinalyses were made in this as in Case II. The maximum specific gravity was 1022, the lowest 1012, an average of about 1017.

In 1880 he was up two or three times at night to urinate.

In 1882 he had headaches.

In 1883 the total urinary excretion was noted as 50 ounces, and Dr. Alexander found granular casts several times. Residual urine was examined for and none found in this same year.

In 1884 it was noted that headache persisted. Hyaline casts were found once, and renal epithelium noted, but many other examinations failed to disclose casts.

In 1887 the albumin rose as high as 0.2 per cent. by weight.

In 1891 the headaches were troublesome again. All this while there was a slight urinary frequency, *e. g.*, in 1893 it was noted that he urinated every three hours, night and day.

In May, 1896, however, he was urinating only once at night. In December of that year he suffered from priapism. This disappeared under bromides. It is stated that the pus was derived from the prostate as well as from the kidney.

In 1897 he had neuralgia in the back of the head, 1 per cent. of pus by volume in the urine. Later in that year it was believed that his tendency to vesical irritability was due to right seminal vesiculitis (because of pain radiating to the testicle and thigh). In October of that year the albumin rose to 0.5 per cent. by weight. In December his bladder became more irritable, he was urinating every three hours, and most depressed by priapism and pain in the right testicle. The right vas deferens was therefore tied off under local anesthesia. During his convalescence he had a slight periostitis of the right tibia. "His kidneys acted very badly, discharging pus in irregular quantities. At one time he was in a very low mental condition." He returned to work, however, and remained very well until July, 1898, when he had hematuria. Late that year his bladder irritability returned with some nocturnal polyuria (38 ounces in nine hours). In March, 1899, specific gravity, 1012, trace of pus, few Gram-negative bacilli, no blood, marked albumin ring; urinating every two and one half or three hours. In 1900 pain in the back of the head; nocturnal polyuria; he was sleepy, his bladder irritable; the albumin again rose to 0.5 per cent. by weight.

In 1901 he became very feeble, mentally as well as physically, drooling from mouth and bladder, and so died, uremic, in 1904, at the age of eighty-five years, at least thirty years from the beginning of his infection.

These 3 cases are most exceptional, for they all represent a grave renal infection persisting for a long time, and yet scarcely incapacitating the victim. The absence of radiography, cystoscopy, or renal functional tests, while regretable, does not vitiate our conclusions. The striking feature of all 3 cases is the absence of any grave acute attacks during the course of the infection. A contributing cause of their longevity was their great wealth. The two men were actively engaged in business until within a few years of their death.

We need not insist, however, upon the fact that the great majority of cases of renal infection run a much briefer course and are subject to many accidents.

Pyonephrosis.—As a rule the patient with pyonephrosis has a tender tumor in the loin. Rarely he suffers from frequent urination. Usually the predominating symptoms are either toxic or septic. The unmistakable clinical picture combines a septic fever with a painful, tender loin, in which palpation readily recognizes a much-enlarged kidney. The ureter catheter discloses great diminution of the kidney function, especially in the phenolsulphonephthalein output, and the presence of pus and bacteria. Indeed, the diagnosis of pyonephrosis by ureter catheter is absolute. The obscure cases are those in which the renal

origin of the infection or intoxication is not suspected and the cystoscope not employed. The subjective sensation in the loin may be entirely absent, the tenderness and tumor may be elicited only by very expert palpation. Under such circumstances if there is fever its renal source may be entirely overlooked; indeed, it must be remembered that an enormous pyonephrosis harboring living bacteria may excite scarcely any pain or rise of temperature. Such a patient complains only of feebleness and loss of weight, together with a little backache and various digestive symptoms, and may pass from one physician to another, the diagnoses varying from dyspepsia to carcinoma of the stomach.

Perinephritis.—The sclerotic and fibrolipomatous types of perinephritis produce no appreciable symptoms beyond those of the underlying renal infection.

Suppurative perinephritis (perinephritic abscess), produces a clinical picture which is often more confusing even than that of intrarenal suppuration. For in the acute cases the localized pain and tenderness may be less marked and the chronic ones may be associated with no pyuria to direct our attention to the urinary organs. It is convenient to describe an acute and a chronic type of symptoms.

Acute perinephritis often results from ferunculosis or follows injury.[21] The attack resembles an acute sepsis and may begin with chills and progress with an irregular fever. The pain is likely to be diffused and increased by respiratory or muscular movements. A costovertebral tenderness may be elicited. Only operation can differentiate this condition from focal suppuration. The patient may recover without operation, or may pass into a chronic suppuration, or die of sepsis. *Chronic perinephritis* may or may not begin acutely. When the onset is insidious and the temperature low, the diagnosis is rarely made until the pus accumulates in sufficient quantity to produce a palpable mass in the loin. The outlines of the mass are usually obscured by tenderness and muscular rigidity. This fact, together with the absence of history or physical signs of infection in the kidney, often establishes a diagnosis; though there is often definite pyelonephritis associated with the perirenal suppuration. The outcome of these cases is that of any other septic focus. They are unlikely to resolve spontaneously. They may discharge into the pleura, the lung, the intestine, or even from the skin or into the pelvic organs. The rapidity of progress and the outcome of the case depend upon the acuteness of the infection and the promptness with which the diagnosis is made and surgical drainage provided.

Townsend[40] has called attention to the fact that chronic perinephritis in children is almost always mistaken for spondylitis or hip disease.

Symptoms of Clinical Types of Renal Infection.—Although the symptoms already enumerated constitute the clinical picture of renal infection, yet the circumstances under which these infections arise determine to a certain extent the resulting clinical picture.

We may enumerate the following:

Renal infection in infancy.
Renal infection in pregnancy.
Urethral chill.
Renal infection due to urethral retention.
Renal infection following surgical operation.
Renal infection due to stone and tuberculosis.
Renal infection due to typhoid fever.
Renal infection due to the gonococcus.

Renal Infection in Infancy.—The infection usually occurs in little girls under two years of age. It is commonly said to be ten times as frequent in girls as in boys; but there is reason to believe that the infection is overlooked in boys even more frequently than in girls. Though commonest in infancy the infection is by no means infrequent in older children. Two clinical types may be noted; the acute and the subacute.

The acute type is characterized by chill and high, but irregular, septic fever usually without any localizing symptoms whatever. The patient may complain of some urinary irritation or of general abdominal discomfort. But the infant does not localize pain in the side. While the temperature is likely to be extremely high the general debility of the patient is relatively slight. Malaria and pyelonephritis are said to be the only conditions that occasion high septic fever with repeated chills in female infants. (Thompson.[22])

The subacute attack is mild and characterized usually by digestive disturbances, abdominal pain and little fever. The case consequently passes for one of intestinal disturbance, and the urine is not examined. But continued or recurrent intestinal disturbance in children, especially if associated with fever, should always lead to the suspicion of renal infection, which can be proven by urinary examination.

The immediate prognosis is exceptionally good. The acute attack, though stormy, usually subsides in the course of two or three weeks; but after the temperature has fallen to normal relapses are to be expected. The relapses occur either at short intervals or, as Birk pointed out,[4] at long intervals throughout the youth of the patient. As a rule the recurrences are mild and are either dismissed as attacks of slight fever or attributed to rheumatism, pneumonia, la grippe, or some other indefinite infection. But examination always reveals either costovertebral tenderness or pyuria, or both.

As already noted these infections apparently subside; but actually a microscopic infection often persists.

Perinephritis is rare in children. It causes restriction of motion in spine and hip, and is mistaken for disease of these joints. It may be diagnosed by palpation.

Renal Infection in Pregnancy.—There are no adequate data on the effect of pregnancy upon chronic renal infections. Kermauner[25] and Albeck[1] have cited cases illustrating the probability that latent renal infection is the origin of the infection during pregnancy. But it has

been shown that in early pregnancy the bladder urine is infected far more often than the urine obtained from the pelvis of the kidney. Hence, for some cases at least, an ascending infection must be granted. Be that as it may, the renal infection that interests the obstetrician is an acute condition. Unless catheterized specimens are examined as a routine measure chronic infection is overlooked.

This acute inflammation is more frequent in primipara than in multipara. Though it may occur as early as the third month it grows progressively more frequent to a maximum extending from the seventh month into the puerperium.

A preliminary bladder irritation and backache are not uncommon. The acute attack is characterized by a sudden rise of temperature, pain and tenderness in the loin or the appendix region, and pus and bacteria in the urine. An irregular sepsis results, varying from little more than a general depression, backache, and slight fever, to the more familiar acute form with hectic temperature and repeated chills.

Although delivery of the child may terminate the acute process, in some instances this does not even begin until the patient begins to get about thereafter. In any event, recovery from the chronic infection persisting after relief of the acute symptoms is usually a matter of months. Subsequent pregnancies often do not cause a relapse of the acute infection.

Urethral Chill.—This acute reaction of an infected kidney to reflex irritation from an infected prostate is, of all the types of acute renal infection, the least likely to drag on in a prolonged sepsis. Doubtless the reason for this is that these cases have free drainage.

The so-called defloration pyelitis is apparently a type of urethral chill. It is an acute renal infection due to laceration and infection of the heligmen.

Renal Infection Due to Retention.—Quite the opposite is the case here. The infection is characteristically chronic and often leads to complete destruction of the kidneys without a single acute symptom. The clinical picture of urinary septicemia predominates.

Acute symptoms, with grave renal deficiency, mark the beginning of infection in kidneys that have long suffered from retention. This condition is most typically illustrated in prostatism (*q. v.*).

Acute attacks of renal inflammation in the course of a chronic retention-infection often result in fever without accompanying loin tenderness.

Renal Infection following Surgical Operations.—Retention of urine follows surgical operations either because the operation itself so injures the abdominal wall that the patient is unwilling or unable to bring the pressure to bear necessary to voluntary urination, or else because the patient's muscular weakness discloses and magnifies a preëxisting cause of urinary retention, such as cystocele or prostatism. In either case the condition is similar to acute prostatic retention. Catheterization if only repeated once or twice, may not infect the bladder. But if

repeated passage of the catheter is necessary, the bladder becomes infected, and ascending infection of the kidney follows. An element often overlooked in these cases is that of partial retention. Thus it is generally believed that when the patient resumes urination, he or she can empty the bladder fully. But this is very likely not to be the case, and the overlooked partial retention can set up or add to an already existing renal infection. Indeed, the condition parallels that of prostatic retention in almost every respect. Its symptoms are the same and its prognosis (like that of prostatic retention) depends largely upon treatment, including the diagnosis of the existence of any local cause of preëxisting retention in the bladder, and the intelligent use of the catheter.

Stone and Tuberculosis.—These special types of renal infection are considered elsewhere.

Renal Infection in Typhoid.—Typhoid bacilli appear in the urine following typhoid fever in probably at least one-third of the cases. The bacilli and pus appear in the urine during the third, fourth or fifth weeks, and persist for an indefinite time thereafter. The infection is usually symptomless and mild; often a mere bacilluria. Yet even after an interval of quiet lasting for years it may cause any of the acuter forms of renal infection. Melchior[28] mentions 1 case that developed acute symptoms after six years, another after ten years. The clinical importance of typhoid infection of the kidney, however, is the fact that these cases are typhoid carriers, and are far more dangerous to the community than they are to themselves.

Gonorrheal Renal Infection.—The precise frequency of renal infection in the course of a gonorrhea is not known. Motz[30] cites cases. When renal infection complicates gonorrhea it is almost invariably due to mixed infection with staphylococci.

In only a few cases has the gonococcus been actually found in the kidney pelvis. (*Cf. Motz.*)

I have seen but one such case. The infection was a mixed one of gonococci and tubercle bacilli.

The infection is usually mild. It may, however, assume any of the acute phases of renal infection. The presence of gonococci in the urine obtained from the pelvis of the kidney must be proven by culture.

DIAGNOSIS OF RENAL INFECTION.

The diagnosis of renal infection depends rather upon the arousing of the suspicions of the medical examiner to the fact that the patient may have a renal infection than upon anything else. Once renal infection is suspected, it can readily enough be diagnosed. Renal infection should be suspected whenever there is pus in the urine, obscure fever, or obscure toxic symptoms.

When renal infection is suspected the diagnosis is made by exami-

nation of the patient by the ordinary physical method, by urinalysis, by cystoscopy and catheterization of the ureters.

Physical Examination.—The physical examination of the patient consists chiefly in palpation of the loin to evoke evidence of tenderness or tumor. The characteristic tenderness of an acutely infected kidney is elicited by sharp pressure in the costovertebral angle, *i. e.*, the angle between the twelfth rib and the mass of erector spinæ muscle.

Tenderness in the abdominal wall, due to muscular rheumatism or other mural inflammation, is to be distinguished from the deeper tenderness excited by kidney inflammation by ballottement.

If the tenderness is but slight this may be elicited only when the patient has taken a deep inspiration. If intense it is accompanied by rigidity of the overlying muscles. This rigidity is much more marked if there is perinephritis than if the kidney alone is involved. The distinction between the tenderness due to infection within the kidney and the tenderness due to perinephritis is not always easy. A small perinephritic suppuration is likely to be mistaken for an intrarenal infection.

When the infection is chiefly in the pelvis of the kidney or ureter, rather than in the parenchyma, there may be points of tenderness along the ureter itself or over the pelvis of the kidney. These points extend from the region of the appendix to that of the gall-bladder. But when tenderness can be elicited at these points it can usually also be elicited in the loin. Palpation for renal tumor should be made primarily by ballottement as follows:

Ballottement.—The physician (in order to examine the right kidney) stands on the right side of the patient, who lies on his back with the knees drawn up and the abdominal wall relaxed. The fingers of the left hand are then pressed flat into the corner between the last rib and the erector spinæ muscle on the right side. The fingers of the right hand are placed flat upon the abdomen external to the rectus muscle and just below the free border of the ribs. As the patient breathes deeply in and out, firmer and firmer pressure is made with the fingers in front, and, finally, when they have been depressed as much as seems possible, and at the moment of abdominal relaxation immediately after deepest inspiration, the kidney is sharply struck from behind by the fingers of the left hand in the loin. If it is either low or large it will be thrown against the fingers of the right hand, giving the familiar obstetrical sensation of ballottement. If tender the patient feels pain.

Ballottement distinguishes a relatively slight enlargement or mobility of the kidney, and differentiates this movable mass from an immovable perinephritic exudate. Large renal tumors or greater degrees of renal mobility are readily recognized by bimanual palpation without ballottement. Perinephritic exudates are felt as doughy immovable tumors that give ballottement. If the suppuration is at all acute these doughy tumors are quite sensitive, and are accompanied by considerable rigidity of the overlying abdominal muscles.

Urinalysis.—With the exceptions cited below the urine passed by the patient with an infected kidney contains pus and albumin. The pus appears in the urine obtained from the bladder by catheter; the albumin is usually present in sufficient quantity to produce a ring by the nitric acid test. It is further characteristic of renal infections that they produce albumin in disproportion to the presence of casts. With a considerable amount of albumin there are often few or no casts.

The amount of albumin varies with the intensity of the parenchymatous inflammation. If this be mild the albumin may fall to a mere trace. On the other hand, nothing else except a considerable amount of macroscopic blood in the urine is sufficient to produce enough albumin to give a nitric acid ring. *Pus does not explain albumin. Albumin,* therefore, *with pus and without casts is the usual urinary picture of renal infection,* as described in the preceding section.

It must not be forgotten, however, that latent renal infection may be so slight that there is no pus, there are even no visible bacteria, and there may be no perceptible albuminuria.

Pus is also absent from the urine when focal suppuration is so hyperacute that no pus is delivered into the pelvis of the kidney from the diseased kidney. In such cases, however, the intense sensitiveness at the costovertebral angle is such as to make the diagnosis absolutely certain. Confirmatory evidence may also be obtained by the ureter catheter.

A third condition in which pus may be absent from the urine is perinephritis. Recent investigations all attribute perinephritis of obscure origin to cortical infection of the kidney. Such infection may not be associated with any infection of the pelvis of the kidney; consequently there may be no pus in the urine.

Renal infection impairs the renal function and therefore results in a lowered specific gravity and lowered phenolsulphonephthalein output, proportionate to the inflammation of the kidney parenchyma.

Grave chronic pyelonephritis or pyonephrosis delivers a urine of low specific gravity in which the pus settles to the bottom like a ropy, flat mud of greenish hue.

Ureter Catheterization.—But although the examination of the patient, the study of the history, and the analysis of the urine all form part of the diagnosis of renal infection, this can neither be complete nor accurate without the passage of the ureter catheter in order to draw urine directly from the pelvis of the kidney. Thus only can the urine from the two kidneys be studied separately, thus only can we estimate the dilatation of the renal pelvis, thus only can we eliminate contamination from the bladder and from the urethra. At the same time the cystoscope shows the condition of the bladder and the inflammation about the ureter orifices which so commonly characterize inflammation of the region above.

Inasmuch as the phenolsulphonephthalein and other tests of renal function are described elsewhere there is no need to repeat them here.

Radiography and Pyelography.—Radiography is essential to exclude stone as a cause of renal infection, and pyelography is often employed in order to outline the retention or dilatation of the kidney, or to place the pelvis in relation to a palpable tumor. But pyelography is usually far less useful than the renal function tests in the diagnosis of renal infection.

Differential Diagnosis.—The diagnosis must differentiate renal infection from infection of other parts of the urinary tract (which often coexist with it) and must locate the infection in one or both kidneys and estimate the gravity of infection in each. The ureter catheter, seconded by the renal function tests and pyelography, accomplishes this with great precision. But in many instances a precatheteral diagnosis may be required. The following rules will supply a hint to the diagnosis of such cases: The diagnosis of "cystitis" means nothing. Inflammation of the bladder is always caused by something else. That "something else" is usually infection of the kidney. Frequent and painful urination may be the only subjective symptoms of renal infection. Fever, digestive symptoms, mental disturbance, or general debility may equally be the only subjective symptoms of renal infection.

Hyperacute focal suppurative nephritis is often mistaken for appendicitis or cholecystitis, and operated upon as such. Yet a tap on the loin distinguishes it. This hyperacute infection is the one least likely to show pyuria.

A large tender kidney may well be a pyonephrosis. It may equally well be a hypertrophied kidney opposite to an infected kidney.

Renal pyuria without bacteria is almost pathognomonic of tuberculosis.

The differentiation between perinephritic and subdiaphragmatic abscess can often be made from the history and evidence of visceral or spinal lesion. In the absence of such evidence a renal origin may be assumed and can often be proven by careful examination.

PROGNOSIS OF RENAL INFECTION.

The prognosis of renal infection has been almost sufficiently described in our enumeration of the clinical characteristics of the various types of infection. The element of trauma and retention is of the greatest importance. The infected kidney that is properly drained, and is not subjected to trauma, is likely to give no trouble to its possessor unless he is overcome by the toxemia of some grave infection. On the other hand, many kidneys that are moderately well drained give no trouble unless there is an added strain put upon the kidney by some slight bacteremia. Such patients reflect in a renal congestion the effects of a slight cold, of a diarrhea or even a constipation.

TREATMENT OF RENAL INFECTIONS.

The treatment of renal infection begins with prophylaxis, an effort to prevent the occurrence of infection or to prevent acute outbreaks of infection. Routine treatment is employed if prophylaxis fails. Operative treatment cuts the Gordian knot when routine treatment fails. But each one of these treatments endeavors to attain certain ends common to them all, so that to repeat in this threefold manner would be but a waste of time.

The Object of Treatment.—The ends to which treatment aspires are five. In the first place to spare the renal parenchyma by diet and hygiene. In the second place, to obtain proper drainage of the infected kidney. In the third place, to employ appropriate antisepsis. In the fourth place, to interfere with bacterial activity by appropriate acidification or alkalinization of the urine. In the fifth place, to wash out the bacteria by diuresis. These ends may be tabulated as follows:

Diet and hygiene.

Drainage.
1. Posture (preventive and curative).
2. Bladder drainage.
3. Ureter drainage.
4. Kidney drainage.

Antisepsis.
1. Preventive (bowel, vagina, bladder, etc.).
2. Medicinal (hexamethylenamin, etc.).
3. Local antisepsis (pelvic lavage).
4. Vaccines.

Acidification or alkalinization of the urine.

Diuresis.

Diet and Hygiene.—The routine diet and hygiene of the sick room comprises the diet and hygiene required for acute renal infections.

But the chronic cases present problems of alcohol, nitrogenous intake, etc. For those patients whose infection is confined to the renal pelvis it is doubtful whether any restrictions are required. As Osler suggested in his essay "On the Advantage of a Trace of Albumin and a Few Hyaline Casts in the Urine of Men Past Forty," the renal infection may be employed as an argument against alcoholic or other excesses; but nothing more.

For those patients whose kidney function is definitely impaired (as shown by blood-pressure or phenolsulphonephthalein) a diet must be selected that does not permit an accumulation of work upon the kidneys. It is all-important that the patient keep lean, work amiably, enjoy his leisure, get plenty of fresh air, and drink no alcohol.

Drainage.—Of the five objects of treatment, the second, namely, drainage, is the one that must be kept most constantly in mind. Without proper drainage other treatment is of no value. With proper drainage other treatment is often unnecessary.

Posture.—The importance of posture as a preventive of renal infection has already been insisted upon. The practical details of this treatment may be confided to the orthopedist. They consist essentially in exercises combining toes-in, hips-down (no "bustle"), abdomen-in, and chest-forward, with resting in the hyperextended position.

Rest should always be employed in the treatment of acute renal infections. Such patients should obey the following rules:

1. Absolute decubitus. The patient should not be permitted out of bed, or to sit up in bed, on any excuse. She—it is usually a woman—must lie flat upon her back as much as possible.

2. If a pillow cannot be absolutely prohibited, only a small one may be granted. Moreover, the patient must lie as much of the time as possible with a small, flat pillow beneath the lower dorsal region. This throws the lower chest forward, markedly expands the lumbar recesses, and places the trunk in the attitude it should retain in the erect position.

Bladder Drainage.—When renal infection is due to urethral retention, relief of this retention usually does all that is necessary in the way of treatment of the infection above. The method of applying this relief is discussed in the sections devoted to the treatment of urethral stricture and prostatism. We need only remark that in certain cases the bladder relief of retention fails, because there has occurred some secondary kink or pouching of the ureter or kidney pelvis above the point relieved by bladder drainage. This then requires relief by ureter or kidney drainage.

Ureter Drainage.—The observant urologist will be impressed by the slight obstruction that often causes grave ureteral retention. Thus he will see the sharpest colics result from the passage of small stones. He will repeat the experiences reported by Lillienthal in the cure of various types of renal retention by the single passage of a ureter catheter. He will observe renal colic following cystoscopy, and due to the passage of clots of blood or pus so small as to be scarcely observable. Hence, he will infer that the ureter catheter must be our first thought in ureter drainage.

The Ureter Catheter.—Albarran was the first surgeon to call our attention seriously to the advantages of drainage by the ureter catheter. He employed the in-dwelling catheter, leaving it in place for ten days at a time and replacing it by means of a long filiform bougie, which could be run up the ureter through the lumen of the catheters he employed (their caliber was 9 or 10 F.). The replacing catheter was then slid over this filiform and left in place for another ten days. In this manner he successfully treated grave chronic retention infections as well as acute ones. Unfortunately this method has somewhat fallen into disuse. We should employ it more often than we do in the treatment of acute or destructive chronic cases when there is no possibility of operating. It is to be remembered, however, that the large-size ureter catheter employed by Albarran is not always necessary. The catheter acts rather as a capillary drain than as a pipe to carry off the

urine. I have successfully employed smaller catheters and felt that, even after they ceased to draw the urine very freely themselves, they drained very effectively by capillarity. I have not been able to prove the curative effects of Albarran's treatment, but I have tided my patients over grave crises by this means.

The ureter catheter is also useful for the treatment of acute renal infection. There is a class of cases, as we shall see, where the question of operation cannot be immediately determined. The patient is so sick that one hesitates to do nothing, and yet not so sick that one feels justified in performing nephrectomy at once. These cases are often much benefited by the single passage of the ureter catheter or by the in-dwelling ureter catheter. But it is to be remembered that the ureter in this respect is not unlike the urethra. Sometimes the in-dwelling catheter helps, sometimes it simply intensifies the acuteness of the inflammation of the kidney parenchyma. Peck[31] has recently recalled to our attention another use of the ureter catheter much insisted upon by Albarran; viz., its employment after operation for hydronephrosis. At the close of operation the catheter is left in the ureter. It is removed at the end of six to eight days. (Peck leaves the catheter in no more than a day or two.)

Operative drainage of the ureter, except by the removal of stone or stricture, is rarely employed. For if there is obstruction in the ureter, by the time it is found that milder measures than operation will not remove it, there is likely to be retention in the kidney pelvis as well, by secondary dilatation. Therefore the operative attack must be upon the kidney; not upon the ureter.

Kidney Drainage.—Drainage of the kidney, except by the ureter catheter, requires the knife. We may dismiss without comment the needle puncture still occasionally advised by our less surgically inclined brethren.

Surgical intervention upon the kidney for the relief of infection is required under two sets of conditions: (1) when the infection is a secondary matter, and stone or retention is the primary object of operation; (2) when the infection is the primary and important manner.

Subsidiary Renal Infection.—The drainage of the infected kidney operated upon for stone or retention should usually be accomplished by means of tube drainage through the wound. Or if no incision in the parenchyma has been made a tube is let down to the incision in the pelvis. It is usually better in these cases not to attempt a tight suture of the kidney pelvis, for the drainage of this does no harm, relieves unsuspected infection, and the fistula always closes before the patient is ready to leave the hospital, if retention has really been relieved. In such cases drainage of the renal pelvis by ureter catheter is useful, as has been already suggested.

Primary Infection.—The infected kidney requires operation under two conditions: (1) for pyonephrosis, and (2) for acute focal suppura-

tion. The considerations in either case are so special that a discussion of them is deferred to page 480.

Antisepsis.—The cleanliness of antisepsis is next to the Godliness of drainage. For it is often possible by means of antisepsis of the bowel, vagina, bladder, etc., to minimize markedly the supply of bacteria reaching the kidney and thus to decrease its infection. It has often been remarked, for example, that a thorough course of bowel antisepsis markedly diminishes (even relieves) the infection of the urine. I have observed a case of chronic pyelitis of a mild type that resisted all treatment until the patient took daily vaginal douches with plain water, thereby controlling a chronic leukorrhea. By these it was promptly relieved. The treatment of cystitis by irrigation of the bladder, especially if the cystitis is due to retention, is a most essential part of the treatment of renal infection. Finally, it is especially important in the case of children to conduct a careful search for any possible source of infection; *e. g.*, tonsils, appendix, etc., and to remove these as soon as may be.

Hexamethylenamin.—But the really important field of antisepsis is in the administration of the so-called urinary antiseptics. Of these there are a great number, but hexamethylenamin occupies a place almost by itself.[23]

Hexamethylenamin is a combination of ammonia and formaldehyde. Its physiological effect is due to the antiseptic effects of the formaldehyde liberated from the drug in acid solutions. Thus, formaldehyde may be obtained from the contents of the normally acid stomach after the injection of hexamethylenamin. The same holds true of the normally acid urine. Burnam laid the foundation for our understanding of the activity of this drug when he proved that it was liberated only in acid solution, and that it was inefficient as an antiseptic in strength of less than $\frac{1}{30000}$. Subsequent investigators confirmed Burnam's observations, though with some indecision as regards the effects of acidity and alkalinity on the liberation of formaldehyde. But George Smith[35] has shown that these misunderstandings are based upon the fact that the acidity must be calculated in terms of hydrogen-ion concentration, and that the appearance of free formaldehyde in alkaline urine is to be attributed to rapid changes in the reaction of the urine from acid to alkaline within the urinary passages. Burnam showed that doses of less than 1 gram, three times a day, were calculated to liberate formaldehyde in antiseptic quantity in the urine of only a very small proportion of patients. Whereas, if as much as 2 grams were given four times a day, 60 per cent. of the patients showed appreciable quantities of formaldehyde in the urine. Smith suggests that the administration of acid phosphate of sodium in 0.5- to 1-gram doses, three times a day, adds appreciably to the acidity of the urine and its contents of formaldehyde. The maximum excretion of formaldehyde is found within a few hours of the administration of the drug. Consequently, the older method of giving the drug in interrupted courses is unjustified.

Nevertheless, hexamethylenamin has a definitely toxic action, both upon the stomach and the urinary organs, due to the liberated formaldehyde. Indeed, a number of cases of hematuria have been reported[11] after the administration of such small quantities of hexamethylenamin as 5 grains, three times a day, or even a single dose of 10 grains. The minor toxic effect of irritation of the bladder and of the kidney pelvis, causing frequent and painful urination, is also due to the liberation of formaldehyde in the urine. Unfortunately, when this irritation occurs it may be difficult to distinguish the irritation of the drug from the irritation of the infection for which the drug is being administered. Under these circumstances microscopic examination of the urine sediment will reveal the fact that formaldehyde irritation is accompanied by a decrease of the amount of pus in the urine, but with a corresponding increase in the number of epithelial cells.

Practically speaking, therefore, the administration of hexamethylenamin should be begun at a dose of 5 to 10 grains, three times a day. After a day or two if this dose does not irritate it may immediately be increased to 20 to 30 grains, three times a day. Meanwhile the acidity of the urine is noted, and if this is found to be low by the ordinary litmus test (which is sufficiently accurate for general use), sodium acid phosphate is administered. When thus administered the therapeutic effects of the drug will be found to vary unaccountably. In some cases it is brilliantly effective, in many others apparently absolutely without effect.

The greatest virtue of the drug is undoubtedly as a preventive of infection of the urinary organs from cystoscopy, operation, or the passage of urethral instruments. For this purpose it should be given in high doses of 15 to 30 grains, three times a day, for one day immediately preceding the operation. It should also be continued during the early convalescence.

The other urinary antiseptics are so far inferior to hexamethylenamin, both theoretically and practically, that they are scarcely worthy of consideration. Salol has a certain reputation; so have the benzoates. But these, like the various compounds of hexamethylenamin, are not worthy of consideration. Their antiseptic effect is slight at best and lacks strict laboratory attestation.

Lavage of the Renal Pelvis.—The place of renal lavage in the treatment of infections of the ureteral pelvis and ureter is not yet fixed. It is obvious that the treatment cannot be applied in all places and to all cases. It requires cystoscopy, and if strong injections are to be used it is much wiser that the patient be in bed in a hospital throughout the treatment. Geraghty[19] emphasizes the fact that cases of long-standing pyelitis and cases with retention of urine in the pelvis of the kidney cannot be cured by lavage. But he has had brilliant results from lavage of subacute cases with solutions of silver nitrate, beginning at a strength of 1 to 500, and increasing until 2 per cent. or 5 per cent. is reached. The stronger solutions cause great pain, but sometimes cure when the

weaker ones fail. He restricts the use of this treatment to those cases that show a normal pelvis of the kidney (by pyelography) and a normal output of phenolsulphonephthalein. We may again call to mind the recognized good effect of the mere passage of the ureter catheter in relieving slight ureteral obstructions. Until we shall have further confirmation or development of Geraghty's observations we may let the subject rest indeterminate. For acute infection, with fever, the benefit of lavage is questionable, though the benefit of drainage by the ureter catheter is, as before observed, often immediate.

Vaccines.—The consensus of expert opinion is decidedly opposed to the use of vaccines in the treatment of infections of the kidney. The method met with faint praise when discussed before the American Association of Genito-Urinary Surgeons in 1910. Since that time no new light has been thrown upon it. Wulff[41] reports excellent results from autogenous vaccine treatment in Rovsing's clinic. But he admits he has not been able to find any similar experiences recorded.

Alkalinization and Acidification.—Much can be done toward controlling the growth of bacteria in the urine by rendering this medium of an acidity or alkalinity unfavorable to the growth of the particular organism involved.

The most brilliant example of this is that of the use of Bulgarian bacilli in the treatment of incrusted staphylococcus cystitis by Caulk. I have found the acidophilus bacillus much better suited for this purpose. It is so efficient in the bladder that it might prove useful if injected into the pelvis of the kidney. But with this one exception no local treatment has been employed to influence the acidity of the urine.

As far back as 1902, however, Betz[3] found that a weakly acid urine was the most favorable culture medium for the colon bacillus. He accordingly eliminated all fluid from the diet in order to concentrate the urine, and administered sodium acid phosphate, 5 grams a day. It is not evident that his treatment was very successful, but since that time it has been found that by alkalinizing the urine it is possible sometimes to reduce the fever and shorten the attack of acute renal infection in children. For the more chronic cases alkaline treatment does not seem effective. Indeed, I have not found it particularly effective in acute cases. But much is claimed for it by some competent observers. The importance of the acidity or alkalinity of the urine has not attracted the wide discussion it merits.

Diuresis.—Quite the opposite to the treatment just mentioned, of concentrating the urine, is that usually employed in the treatment of renal infection, viz., diuresis. Diuresis may be obtained by the administration of drugs, notably the citrates and acetates; but apart from the alkalinity of the urine induced by them it is questionable whether they have any great diuretic value.

Diuresis is much better obtained by inundating the patient with water. He may be made to drink as much water as possible, colon irrigation may be added to this, or if the patient is confined to bed the

Murphy rectal drip may be employed. In surgical emergencies subcutaneous and intravenous infusion have a place.

When the infection is acute it is wise to push water with discretion, for inundation with water is likely to do more harm than good by adding to the renal congestion. There appears to be one exception to this rule, however, viz., the retention infection. Thus when a prostatic is relieved of any considerable retention by an in-dwelling catheter he should be given a sharp course of diuresis by the Murphy drip or colon irrigation combined with plentiful administration of water by mouth.

With one exception diuresis is of little value during the more chronic stages of renal infection. This exception is the mild case of chronic renal infection which can be treated at a diuretic springs. I have known several such cases to get rid of their visible bacteria by going to a spring where they could simply drink large quantities of water every day. Yet the same effort at water-drinking undertaken at home appeared to be without any effect.

The Treatment of the Various Types of Renal Infection.—Having thus considered the elements of the treatment of renal infection, let us turn to the specific condition which these methods of treatment have to be used again. We may enumerate the following:

1. Acute renal infections.
2. Chronic pyelonephritis.
3. Pyonephrosis.
4. Perinephritis.
5. Pyelitis follicularis or encrusted pyelitis.

Treatment of Acute Renal Infections.—In describing the symptoms of focal suppurative nephritis we grouped them with acute renal infections in general and described mild cases, severe cases, and fulminating cases. The mild and the severe cases may be treated in the same manner. They require absolute dorsal decubitus, with a pillow under the lower ribs in order to widen the costovertebral angle. They should be searched for foci of contributary infection in the bowel, the vagina, the bladder, the tonsils, etc. One has the choice between using hexamethylenamin in doses of 1 gram or more, three times a day, with sodium acid phosphate in similar doses to increase the acidity of the urine; or to employ sodium citrate or acetate in gram doses, three times a day, for the purpose of alkalinizing the urine and rendering it a less fit culture medium for the Bacillus coli (if the Bacillus coli is the infecting agent). Better results are usually obtained by the acid than the alkaline method of treatment. (They may be alternated.) At the same time diuresis is obtained by encouraging the patient to drink eight to ten glasses of water a day; but not "as much water as possible."

In children no local treatment is necessary, but for adults, if the case is fairly severe or protracted, one may perhaps bring it to a more speedy conclusion by the use of the in-dwelling ureter catheter.

I question the advisability of the use of pelvic lavage for acute cases. The patient should not be permitted to get out of bed until the temperature has been below 100° F. for several days.

One may be tempted to operate upon the severe cases either because of their intensity or because of their protracted course. The latter reason never justifies operation unless for the purpose of relieving retention in the ureter or in the urethra. But if the attack is sufficiently acute—if it is indeed a fulminating attack—it may be necessary to operate at once in order to save the patient's life. If there is any doubt as to the gravity of the situation one may be guided by the fact that children almost always recover without operation, and adults in desperate straits may be helped by the in-dwelling ureter catheter. But if the temperature goes to 105° F., and stays there, or if there are repeated chills, one should not wait for the patient to show the systemic effect of the poisoning, but prompt nephrectomy should be performed. The result of this operation is most brilliant. The mortality is low. (I have operated four times, in desperate cases, with no deaths.) The temperature promptly falls to normal and stays there. But it is to be remembered that acute infection of one kidney is usually accompanied by a chronic infection of its fellow, and this fellow may in its turn undergo an acute attack if the one kidney is removed. Therefore only the most desperate straits justify nephrectomy.

On the other hand, milder operative measures have been advised for milder types of infection. Thus Brewer advises decapsulation for the milder cases; others advise nephrotomy. It is questionable whether cases that are relieved by these measures would not be much better relieved by being let alone and treated medically. The trauma of operation is the very thing calculated to induce an acute attack of renal infection. It is questionable whether this trauma does not do as much harm as a nephrotomy or decapsulation do good.

Decapsulation for Non-surgical Nephritis.—Decapsulation of the kidney for the treatment of chronic Bright's disease was introduced by Edebohls[16] on the theory that formation of a new capsule provides a better blood supply to the parenchyma of the kidney, and so is calculated to cure chronic nephritis. His operation was a simple decapsulation. European observers, however, finding that simple decapsulation did not increase the blood supply of the kidney, suggested and employed the modification of introducing the kidney into the peritoneal cavity after decapsulation and surrounding it with a capsule of omentum. It is doubtful, however, whether even this procedure actually increases the blood supply of the kidney. Moreover, chronic nephritis is not due to poor blood supply, nor does it improve after decapsulation.

On the other hand, decapsulation has been employed in the treatment of such acute conditions as moderately severe focal suppurative nephritis, uremia or eclampsia in the course of chronic Bright's disease, and the so-called hemorrhagic and painful type of nephritis. It has

been definitely established that attacks of acute renal congestion, whether medical (*e. g.*, eclampsia) or surgical (focal suppurative nephritis), may be relieved by decapsulation or by nephrotomy. The operation appears to be chiefly a blood-letting one in either case, and no adequate comparison has been made between the effect of the two procedures. On the other hand, it is equally certain that the trauma of operation may, as suggested in the preceding section, do more harm than the decapsulation or nephrotomy can do good. The mortality of these operations is extremely high. Pousson[32] says that the mortality of operation in acute medical cases is *only* 13 per cent.

Although certain brilliant cures have been reported of cases in uremia, nevertheless most observers agree that as good results may be expected from medical treatment as from decapsulation or nephrotomy. I remember two instances in which pus disappeared from the urine, following exploratory nephrotomy, which revealed nothing beyond nephritis, and I have operated three times for postoperative anuria without a single success.

The success of nephrotomy or decapsulation in the treatment of painful or hemorrhagic nephritis is attested by many reports. But inasmuch as it is known that pain and bleeding usually arise from conditions that can be definitely diagnosed, at least by operation, and inasmuch as these operative cures are usually reported without very definite pathological findings, they are almost an index of diagnostic failure, and deserve to be classed among those very unsatisfactory operations the results of which are independent of the knowledge or skill of the operator.

Treatment of Pyelonephritis.—Practically speaking, the treatment of pyelonephritis is largely the treatment of its complications. Thus stone, attacks of retention, and attacks of acute nephritis require appropriate surgical treatment. On the other hand, patients with chronic pyelonephritis, without any intercurrent attacks or complications, usually suffer so few symptoms that they do not willingly submit to treatment. Furthermore, the treatment of such cases is singularly inefficacious. If the pyelitis is slight, amounting to little more than a bacteriuria, it may be conquered by the administration of hexamethylenamin or by pelvic lavage, as previously described. But the treatment is tedious and by no means guaranteed to cure.

On the other hand, cases of graver infection with dilatation of the renal pelvis and slight retention may not suffer from any intercurrent attacks of importance. Yet the kidney function is definitely impaired and the sclerosis of the renal parenchyma constantly progresses. Such cases are the bane of the urologist. Much may be done for them by elimination of the sources of infection in bowel, vagina, or bladder, and regulation of their mode of life may somewhat delay the progress of the inflammation. But the ureteral obstruction is not sufficiently marked to be relieved by operation, and the inflammation is too deep-seated to be affected by pelvic lavage.

It is not to be forgotten, however, that many such cases depend upon slight *urethral* obstruction, the relief of which definitely prolongs the patient's life.

Treatment of Pyonephrosis.—The treatment of pyonephrosis is surgical. If the function of the opposite kidney and the patient's general health are such as permit nephrectomy this should usually be performed at once. But certain cases of pyonephrosis are actually due to a stoppage of the ureter by the thickness of the pus in the pyonephrotic sac. Such cases may be entirely cured by simple nephrotomy. Furthermore, a large proportion of cases of pyonephrosis are associated with grave impairment of the function of the opposite kidney. For such, preliminary nephrotomy should be performed, the kidney not being disturbed from its bed. The whole operation may, in many instances, be conducted under local anesthesia, since it consists simply in the exposure of the lower pole of the kidney, and a puncture through this for drainage. Then the patient is permitted to go about with a tube in his side until the general health or the function of the opposite kidney have improved sufficiently to permit nephrectomy. It is to be noted that the mortality from nephrectomy for pyonephrosis of non-tuberculous origin is much higher than that from nephrectomy for tuberculous pyonephrosis. Thus I have had 4 operative deaths from 53 nephrectomies for tuberculosis, and 4 operative deaths from 10 nephrectomies for pyonephrosis due to bacteria other than the tubercle bacillus.

Treatment of Perinephritis.—Sclerolipomatous perinephritis requires no treatment. Though suppurative perinephritis may possibly subside without operation, as soon as the abscess is large enough to be diagnosed it should be drained. It is usually wiser not to interfere with the kidney at the time the perinephritic abscess is drained. But if the kidney is pyonephrotic or contains stone or opens largely into the perinephritic abscess, nephrotomy or nephrectomy is called for at the time of the draining of the perinephritic abscess.

Treatment of the Unusual Types of Infection of the Renal Pelvis.—There is no *treatment of pyelitis follicularis.*

Treatment of Leukoplakia.—The situation here is essentially the same as that for pyelitis follicularis. But cases such as have been reported by Beer, with renal colic due to the passage of masses of epithelial cells from the leukoplakia, may be relieved by pelvic lavage or may require nephrectomy.

Treatment of Incrustations of the Renal Pelvis.—Caulk has succeeded in removing incrustations by the friction of the ureter catheter. Injections into the renal pelvis of acidophilus bacillus might prove of great service in the treatment of such cases. If the kidney is pyonephrotic it should be removed.

Treatment of Postoperative Renal Infection.—For purposes of treatment postoperative renal infection may be considered comparable to renal infection due to urethral obstruction, as by prostatic enlarge-

ment. Preventive treatment is of the greatest service, and consists of the administration of large doses of hexamethylenamin as soon as catheterization is necessary. If in spite of this the bladder becomes infected, and continued catheterization is required, the best treatment is the in-dwelling catheter until such time as the patient can be up and about or is able to empty his own bladder. It is especially to be borne in mind that even when the patient begins to urinate he is likely to empty his bladder only partially, and thus the renal infection is encouraged at the very time when the patient appears to be doing well. It is safer to continue the in-dwelling catheter too long rather than to omit it too soon.

Treatment of Renal Infection in Pregnancy.—The pregnant woman with pyelonephritis, however mild, should be considered in grave danger of acute retention and acute renal infection. To guard against this she should drink largely of water, take hexamethylenamin as constantly and in as large doses as can be managed, should especially avoid all physical strain, and should lie down as much of the time as possible. The urine should be examined at least once or twice a week, and at the first increase in albumin or pus, or the first rise of temperature, she should be treated as though suffering from acute renal infection, put to bed with a pillow under the lower chest, and hexamethylenamin sharply pushed. If the infection progresses in spite of this treatment the in-dwelling ureter catheter should be applied for as long a time as is necessary to terminate the acute attack. When this treatment fails the choice lies between terminating the pregnancy and nephrectomy. Fortunately the severe infection usually occurs quite late in pregnancy or even during the puerperium, so that there is often no grave objection to terminating the pregnancy. But Davis[14] protests against this, quoting Stoeckel's aphorism: "pyelitis is a complication of pregnancy; not pregnancy of pyelitis." Induction of labor may only encourage delay in proper surgery. If any operation is to be performed, it should be upon the kidney.

Treatment of Renal Infection in Children.—The treatment differs from that of adults in several particulars. In the first place the acute attacks are likely to subside spontaneously, be they ever so intense. In the second place the ureter catheter treatment is obviously impracticable. In the third place, though the child may be put to bed, it cannot be kept upon its back. Finally, the alkaline treatment is said to be particularly efficacious in children as compared with the treatment by hexamethylenamin.

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CHAPTER XIII.

BILHARZIOSIS.

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BILHARZIOSIS, or endemic hematuria, is an infection with one of the trematodes or fluke worms, the Schistosomum hematobium, and is characterized primarily by hematuria and other symptoms of cystitis or proctitis, or by both. The first discovery of this parasite as a cause of endemic hematuria was made by Bilharz in 1851, and from him the disease gets its name.

Distribution.—The disease has long been recognized in Egypt, the French army surgeons having described it in 1800. That it has long prevailed in that region was proved by Ruffer when he discovered eggs in mummies which dated back to at least 1000 B.C. It is also prevalent in many other parts of Africa, especially the eastern side down to the cape. It is likewise met with in Asia, India, Syria, and Mesopotamia, and sporadic cases occasionally appear in all parts of the world, as the parasite happens to be transported by some infected person. Postmortem examinations in Egypt have shown that at least 50 per cent. of the total population are infected. Examination of school children in Cairo at one time showed a percentage of infection varying from 50 to 80. Two of the patients reported later and stated that among their boyhood friends it was the rule and not the exception to pass bloody urine at some time or other.

Etiology.—The infecting parasite is a bisexual trematode, one of the schistosomidæ. The male is 12 to 15 mm. long and 1 mm. broad. The two sides of the worm are folded ventrally, forming the gynecophoric canal, in which the adult female is partly enclosed. The surface of the male is covered with small prominences which may help in holding it in the vein. It has an oral and a ventral sucker placed close together. The female is about 20 mm. long and much more filiform. These worms when young live in the portal system in the liver, but becoming mature go to the portal vein, where the male and female unite, and then migrate into the mesenteric, vesical and hemorrhoidal veins, where the female lays the eggs which are the cause of the symptoms. Just why the migration should be in this direction against the blood stream is not known, although Looss has suggested a chemical attraction toward the bladder.

In Egypt the outbreak of the greatest number of cases comes a short time after the rains, and from this and other evidence it is believed that the incubation period is between one and three or four months in the majority of cases.

Having gone as far as possible, the female deposits the eggs in the small capillaries in the wall of the bladder and rectum. The eggs are about 0.16μ by 0.06μ, and contains a terminal spine. They somehow work through the tissues toward the mucus membrane and there form various more or less characteristic lesions. Rupturing into the bladder they are voided with the urine. How long the journey through the bladder wall is cannot be definitely stated, but the presence of living miricidia in the urine is not proof positive that the worms themselves are still alive. The eggs may become calcified in the tissue on the way through.

How long the worms live and produce eggs is not known, but in the majority of cases they probably are not active over three years. although in certain instances they are known to have lived longer, in one case nine years and in another fifteen years after the first symptoms.

After entering the urine the egg may open and the miricidia escape, but unless water is added it soon dies. If voided into water it breaks loose more quickly and lives longer, having the power of motion for thirty-six to forty-eight hours.

From theoretical reasoning there should now be an intermediary host, perhaps one of the crustaceæ, but as yet it has not been discovered. Moreover, the peculiar geographical distribution of the infection is hard to explain without such a secondary host. (Mauson.) It has been considered more and more probable that man is directly infected. This may come about through the alimentary tract or the miricidium may enter directly through the skin while the person is wading or swimming. The last theory has not been certainly proved for the human individual, although it has been proved experimentally in animals with a slightly different species, the japonicum. Intestinal infection seems unlikely, as the miricidia is killed by a very weak HCl solution. In some parts of Africa the natives believe the infection enters directly by urethra, and they make use of various devices to prevent such an occurrence. The story of one of the reported cases is interesting in this connection; he was one of a family of six boys, one of whom never learned to swim, and he was the only one not infected.

Pathology.—The eggs act as foreign bodies in the tissues and cause a marked round-cell infiltration in the tissue near them. They tend to go in groups, and as they work through the tissue they leave behind an interstitial tissue fibrosis with thickening and stiffening of the bladder or rectal wall. As they reach the surface of the bladder they form numerous small whitish, papular elevations surrounded by a reddened areola anywhere on the bladder, though more commonly on or near the trigone. If there are a greater mass clustered together they may form a tumor of varying size, sessile, with an irregular nodular surface which bleeds very easily, and easily mistaken for carcinoma. In severe cases the bladder wall may be covered with these tumors. In rupturing into the bladder an irregular ulcerated

area may be left. The long continuance of this process may result in a bladder which is thickened and much stiffened. The presence of the worms around the lower end of the ureter may cause an infiltration and ulceration of the wall, with resulting stricture, and then a hydronephrosis, or, in the majority of cases, due to the almost inevitable infection, a pyonephrosis. Very rarely, indeed, are the eggs found in the pelvis of the kidney itself, though they have been demonstrated there in a few cases. Likewise infection of the urethra may result in ulcerative infiltration and a very bad stricture. Behind this stricture continued ulceration and burrowing often result in one or more fistulæ. These may be very numerous and extremely annoying, and if the bladder is extensively diseased, practically incurable. The seminal vesicles and prostate may become involved, and in that case ova can be found in the semen. The tumors in the bladder may easily become encrusted with lime salts, and either remain as large encrustations or form the nuclei of even more troublesome stones.

Symptoms.—The presence of the worms causes no symptoms. It is not until the eggs are deposited in the walls of the bladder and rectum and begin to work through with the accompanying reaction that the host is troubled, and then only in proportion to the tissue change. The presence of the interstitial fibrosis causes naturally some vesical irritation, but nothing more. A little later, as the eggs begin to ulcerate through, hematuria may be the only symptom. In the majority of cases this is all the patient ever has, and it gradually quiets down and no further trouble is ever experienced. In the more severe cases other symptoms of cystitis intervene as the bladder becomes ulcerated or infected, or both, and if stone formation occurs all the pain and suffering from that are added. When stricture occurs that likewise adds its quota. As the ureter becomes narrowed any or all of the complicating symptoms due to renal retention and infection occur. One of the cases here reported had a normal appendix removed several years ago for what was probably the early stages of a strictured ureter.

Diagnosis.—The diagnosis rests on finding the ova in the urinary sediment. The presence of the tumor in the bladder may simulate a carcinoma. The stone, stricture, and fistulæ should not lead one off the track as to their origin. Hydro- or pyonephrosis should be recognized as in the cases of other origin.

Prognosis.—This in general is fairly good, but in any particular case rests on so many factors, such as the degree of infection and its extent, that it cannot be given with any accuracy. In cases in which the bladder alone is involved the disease runs its course, dies out, and that is the end. The infection may be so massive that the walls of the bladder are permanently thickened and stiffened, and an incurable cystitis engrafted because of the tissue change. Or the stricture of a ureter or even of both may change the picture from a comparatively harmless to an extremely serious condition. In other words, the prog-

nosis depends on the chance of kidney involvement and of more serious bladder infections and changes following urethral stricture and urinary sinuses, and it is not possible to estimate these probabilities with statistics.

Treatment.—There is no treatment for this disease. Symptoms and complications should be treated as they arise, just as the same conditions from other causes would be treated. All of the urinary antiseptics have been tried and, except as they should be used to limit urinary infection, are of no value. Extract of male fern has been thought of some use, but without any very good reason. The hematuria is rarely of serious degree, and bladder washes, especially with a 5 per cent. solution of quinin, are the main form of treatment. In one case in which the bleeding came from a single tumor mass on the roof I used the high-frequency cauterizing current, with complete relief of bleeding. Beyond this, treatment should be directed toward the complications as they arise.

The following three cases illustrate different features of the disease:

Case I.—Patient of Dr. Cabot and Dr. Honej. Mr. H., aged twenty-eight years. Born in South Africa in same village as Case II. Hematuria at intervals since he can remember. Cystoscopy in February, 1915, showed on the posterior bladder wall exactly in the median line a nearly healed ulcer.

Case II.—Patient of Dr. Young and Dr. Honej, aged twenty-six years. Almost constant slight hematuria since early youth; no other symptoms. Cystoscopy shows bladder essentially normal except for small, sessile, nodular tumor on roof, which bleeds easily. Fulgurated twice with cessation of hematuria. Both ureters were uninvolved in this case.

Case III.—Massachusetts General Hospital, genito-urinary service No. 100. Italian who had never been in any of the regions where infections ordinarily arise. Complaint, painless hematuria. Cystoscopy shows two small sessile, nodular tumors on roof. Thought to be carcinoma. A radical transperitoneal resection of tumors was done. Slow convalescence. Discharged relieved. Eggs could never be found in the urine after operation. Section of the specimen showed eggs and the worms.

CHAPTER XIV.

ECHINOCOCCUS.

BY EDWARD L. YOUNG, JR., M.D.

AN echinococcus or hydatid cyst is the cysticercus stage of the Tenia echinococcus, a cestode which requires, as a rule, two hosts for its full life cycle. As a tape worm it lives most commonly in the duodenum of the dog, though it is also found in other carnivorous animals. It fastens itself to the mucous membrane by means of a row of hooklets which encircle the head, and also by means of four suckers placed just beneath. The worm consists of only a few segments, the last of

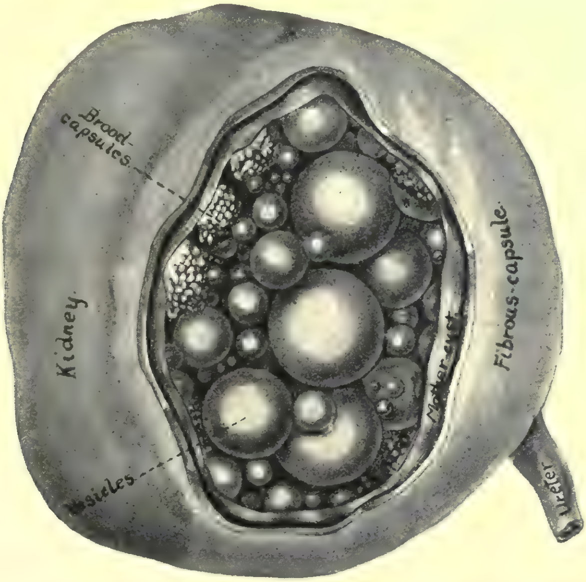

FIG. 186.—Colony occupying the sinus of the kidney. The kidney is seen flattened out on the surface of the cyst. (From J. Bland-Sutton.)

which contains the ripe eggs encased in a gelatinous membrane which protects them for some time after leaving the body. After expulsion from the carnivorous host the eggs may find their way into any one of twenty-seven different animals to complete the second stage of their development. The means of transmission to man, who is one of the twenty-seven, are varied; in Iceland, where dogs are almost part of the family, sleeping in the same room and often eating out of the same

dishes, direct contamination is easy. Or the excreta containing the eggs may be used as manure, which makes green vegetables a source of infection, or they may be washed into some supply drinking-water and thence get into the system. When in the stomach or intestine the egg develops into the larval stage, and this embryo by means of its hooks, burrows into the wall of the gut and thence into a vein, and there it is carried along until it finds a lodging-place and starts to grow. It is easily seen that kidney infection is not common in proportion to other cases, as the larva has to go through the liver, heart, lungs, and back, to and out of the heart, before it is even started in the systemic circulation for the kidney. Collected statistics of many reported cases show a percentage of 1 to 5 per cent. of renal infections in proportion to total cases, and men who see considerable cf this disease say that it is probably even lower.

Distribution.—The disease is common in Iceland, where it is estimated that one-sixth of the population is infected; common, though less so, in Australia and Argentine Republic; not uncommon in France, Italy, Greece, and Germany, and rare in America.

Age.—Seventy-four per cent. of all cases occur between the ages of twenty and fifty years and 59 per cent. between the ages of twenty and forty years. The extremes of age as reported in the literature are three months and seventy-four years.

Sex.—There is no striking favoritism in the preference of the disease for male or female. Some writers find a preponderance of males affected, but still others find the females in the lead, so that in a large series of cases the honors are even.

The disease is nearly always unilateral, both kidneys being very rarely diseased. Either side seems to share equally in the infection.

Multiple cysts in the body are very rare. Nicaise found only 37 cases.

Pathology.—When the embryo starts to develop, its rate of growth is at first very slow, and at the end of six months the cyst may be only 15 to 20 mm. in diameter. It may continue to increase in size very slowly, as cases have been known to exist for twenty years without any serious symptoms, or it may begin to grow more rapidly as it gets larger. It acts as a foreign body in the tissues, and is consequently surrounded by a reactionary wall of fibrous tissue from which it has no clear line of cleavage. Because of its slow rate of increase the rest of the kidney has a chance to undergo compensatory hypertrophy for a long time before it is actually put out of business by the pressure of the large tumor. The wall of the cyst consists of two layers: an outer or hydatid membrane, and an inner or germinal layer. From this latter appear small papillæ or buds which increase in size and become small cysts or brood capsules, inside or outside of which the scolices or new tenia heads appear. Or from the mother cyst may develop daughter cysts similar in the layers, and in their method of propagating the brood capsules and scolices. The brood capsules are

liable to burst and let the scolices float around in the fluid, and in case of rupture of the mother cyst a new hydatid can arise from the scolix. The disintegration of the scolices releases the hooks, which are characteristic of this disease when found in the sediment of urine. An hydatid may be sterile, but only if small; if they grow larger than a hen's egg they are rarely sterile. The fluid in the cyst is colorless and neutral or slightly acid, 1007 to 1015, and contains some kind of a leukomain or toxic substance which, in case of rupture into the peritoneum, can cause symptoms varying from a mild attack of urticaria to a kind of anaphylactic shock which may be fatal.

The growth generally starts in one pole, rarely in the perirenal tissue, or just under the capsule. It is common for it to rupture into the pelvis of the kidney, rare for it to rupture into another organ. In the latter case always, and in the former case occasionally, the cyst becomes infected, and we have to deal with a pyonephrosis. Occasionally the cyst dies and the contents become inspissated.

Symptoms.—As long as the hydatid cyst does not rupture into the renal pelvis, the peritoneum or some adjacent organ, the symptoms depend entirely upon its size and presence as a tumor encroaching on other tissues and organs. There may be a sense of weight with a more or less constant ache in the lumbar region. The tumor may cause obstructive intestinal symptoms from pressure on the gut, or minor digestive symptoms from pressure on the stomach. The tumor may become readily palpable and from its mere presence send the patient to a physician. There are no urinary signs or symptoms under these conditions. If the cyst ruptures into any adjacent organ, the stomach or intestine, the picture changes to that of pyonephrosis, with all its attendant symptoms. If it ruptures into the peritoneum a peritonitis is started and absorption of the leukomain present may cause very marked and annoying urticaria, and even in extreme cases symptoms of anaphylaxis. The peritonitis is generally a low-grade affair, but in certain cases results fatally. If the cyst ruptures into the renal pelvis an attack of renal colic results, lasting until the contents of the cyst have been passed down the ureter. Hematuria nearly always accompanies such an attack. The cyst may now become infected, and the picture again changes to that of pyonephrosis. Or in a certain number of cases the patient never has any more trouble, since the emptying of the cyst has stopped the process. What is most likely is that the disease will remain quiescent for a few weeks or even months until the process is repeated with another attack of renal colic. With each succeeding attack there is generally less pain as the ureter becomes somewhat dilated, allowing the daughter cysts to escape more easily.

Diagnosis.—Before rupture the diagnosis is that of an abdominal tumor. Its relation to the large intestine does not help, as like any renal growth it may be above, below, or behind the colon. Bismuth x-rays rule out an intestinal origin for the tumor. An injected radiograph of the kidney will almost surely demonstrate the fact that the

renal pelvis has been encroached upon by a neoplasm and will show in a majority of cases that the tumor is renal in origin. But to differentiate at this time between this tumor and a hypernephroma or polycystic kidney is more difficult. The fixation test of the blood described by Lanboy and Parvu is of great value, as it is apparently, at least so far as we know, a specific reaction. The blood in most cases shows a considerable eosinophilia which may run very high. Hydronephrosis can be excluded both by measuring the capacity of the renal pelvis and by the injected radiograph. These tumors are rarely fluctuant because of the thick, stiff wall, but the much-described fremitus or thrill can occasionally be obtained. It is best brought out, if at all, by placing the palm or palmar surfaces of the fingers on the tumor and striking it smartly with the other hand; a thrill, as the daughter cysts hit each other and the mother cyst wall, may be communicated to the stationary hand. For some time after the rupture of the cyst into the pelvis the diagnosis can be made by finding the hooklets in the urinary sediment, and often immediately after rupture the whole cysts can be found which have come unruptured down the ureter and out the urethra.

Prognosis.—There is no rule of thumb to go by; it may vary from a relatively harmless to a fatal disease. Certain cases develop very slowly and cause no trouble for years. A certain proportion of cases which rupture into the renal pelvis never have any further trouble, spontaneous recovery apparently taking place. Boockel reported 6 out of 29 cases which were cured this way. Rupture into the stomach or intestine is a serious complication, as infection of the cyst is at once added. Rupture into the peritoneal cavity has been known to cause sudden death; it will surely cause some peritoneal reaction, and may result in the development of new cysts from the scolices. Rupture into the renal pelvis may result in infection and a pyonephrosis have to be dealt with. An uncomplicated case, in which the size of the tumor does not make operation in itself extremely difficult, should show a comparatively low mortality from operation and a large percentage of cure.

Treatment.—The treatment is always operative as soon as a diagnosis is made. When the kidney is largely or entirely destroyed, or if only partially, when resection is impossible, nephrectomy is the operation of choice, provided that it can be done without too great danger of rupturing into the peritoneum during removal. The presence of infection strengthens the indication for nephrectomy. What few statistics we have show a much higher mortality from the transperitoneal route (32 per cent.) than from the lumbar route (8.5 per cent.).

In a few cases resection will be found possible where one pole only is involved, and where the surrounding tissue reaction has not been too great, and where rupture into the pelvis has not occurred. This has been successfully done, but is applicable to only occasional selected cases.

In very rare cases the cyst is attached to the kidney by a pedicle, and the kidney itself is intact. In such cases removal of the cyst is all that can be required.

In very large cysts always, and in the smaller cysts occasionally, marsupialization is the simplest and safest operation, and in the long run gives good results. The length of time for healing is the main disadvantage, as the resulting fistula may persist for several months. To prevent spreading the disease on opening the cyst is important, and the best methods of accomplishing this are, first, to inject some 1 per cent. formalin into the sac and wait a few minutes before opening, or to suture the cyst wall to the skin and open a day or two later. If it is possible to dissect out considerable of the cyst wall and suture the cavity together the length of time required for healing may be much shortened.

Following are histories of three cases which have occurred at the Massachusetts General Hospital:

Vincent de Lilis. East Surgical, No. 197628. Male, aged thirty-four years. Born in Italy. Admitted to accident room, with diagnosis of subacute perforation of stomach.

Family History.—Negative.

Personal History.—Negative.

Personal Inspection.—Six weeks ago began to have a heavy feeling in the epigastrium. This was most marked after eating and decreased in intensity until next meal. Ten days ago this became a pain confined to epigastrium; no nausea or vomiting. Five days ago pain became worse, confining him to bed. No chills. One month ago some burning micturition but no hematuria or other urinary symptom.

Personal Examination.—Negative except for marked tenderness and muscle spasm in epigastrium, most marked two inches above umbilicus. No C. V. T. or spasm; however, half of abdomen soft and not tender.

Urine: N; acid; sp. gr. 1026; trace, 0; no sediment.

Immediate operation. Abdominal incision showed nothing intraperitoneal but mass about right kidney. Kidney incision then made and kidney found to be one large cyst the cavity going about four inches up into liver. Kidney removed and cavity washed out. Wound drained. Normal convalescence.

One month after operation echinococcus fixation test positive.

Dominic Serino. Hospital No. 194553. G. U. Service. Male, aged twenty-three years. Born in Italy.

Family History.—Negative.

Personal History.—Negative. As a boy had a dog which he played with a great deal, and used to sleep with it.

Personal Inspection.—Two years ago passed one small colorless bean-like body in his urine, accompanied by pain and blood. Felt perfectly well afterward. Five months later a similar attack, with several cyst-like bodies, and since then attacks every three to five months.

Personal Examination.—Negative except for the fact that the spleen was easily felt. Patient brought in two unruptured cysts which proved to be broad capsules from an echinococcus cyst. Cystoscopy showed a normal bladder and both ureters were easily catheterized with flow of clear urine from each.

Intravenous red test. Time. Amount in fifteen minutes. Right, four minutes, 50 per cent.; left, six minutes, 4 per cent.

Cultures from both sides showed no infection. X-rays negative. Injected *x*-ray showed an abnormal pelvis. Complement-fixation test for echinococcus positive. Nephrectomy was done, with normal convalescence. Four days later fixation test was moderately positive. Twenty-six days later fixation test was negative. Discharged relieved.

Harry Paulas. East Surgical, No. 196614. Transferred from East Medical Service, with diagnosis of retroperitoneal tumor.

Family History.—Negative.

Personal History.—Negative.

Personal Inspection.—Pain in l. u. q. fifteen years ago and noticed a mass at that time. Has grown slowly until two months ago, and since then very rapidly. Cutting pain in l. u. q. radiating down into thigh. Vomiting about twice a week for past month.

Personal Examination.—Negative except for rounded tumor filling left abdomen, extending to umbilicus on side and half-way to pubes below. Surface irregular; moves with respiration.

Urine: N; acid, sp. gr. 1028; trace, 0; rare case; leukocytes and red blood cells. Wassermann negative. Guaiac on stools; positive. Renal function 15 per cent. in first hour. Cystoscopy shows normal urine from each side with equal, normal function. Operation showed a tumor attached to kidney and a nephrectomy was done. Normal convalescence. Ten and thirty-five days later fixation test was still strongly positive.

Pathologist's report: Specimen consists of a kidney containing an elongated tongue-shaped mass, measuring 8 by 18 cm., attached to one pole. The surface is fibrous and fatty and on section is filled with echinococcus vesicles. Its base is formed by a portion of the kidney cortex, which is completely walled off from the rest of the kidney substance. The rest of the kidney shows nothing noteworthy.

CHAPTER XV.

TUBERCULOSIS OF THE KIDNEY AND URETER.

By RICHARD F. O'NEIL, M.D.

The term renal tuberculosis signifies the destructive lesions produced in the kidney by the introduction, retention and colonization of the tubercle bacillus of Koch. Renal tuberculosis may be divided into an acute and chronic form, the former being a part of the rapidly fatal acute miliary tuberculosis, and having no interest for the surgeon. The so-called toxic tuberculous nephritis, and tuberculous albuminuria, are more or less synonymous and are secondary conditions which will be considered later.

Chronic tuberculous infiltration of the kidney does not occur as the primary focus in the body, but is secondary to some active or remote focus in some other structure or organ, as the lungs, glands, joints, etc. In two-thirds of the cases of renal tuberculosis coming to autopsy the findings show an active or healed lesion in the lungs, mediastinal or mesenteric glands. It is not infrequently associated in the male with genital tuberculosis. In 258 cases of genital tuberculosis, reported by Barney and Keyes, 38 were associated with renal lesions; in 22 cases the renal lesions were diagnosed after the development of the process in the epididymis or prostate, and in 16 the renal condition was primary. The kidney is, however, the primary focus in tuberculous infections of the urinary tract, and when the process is spoken of as being primary in the kidney, it is in this respect. Renal tuberculosis occurs as a disease of young adult life and is most common between the ages of twenty and forty; this is borne out by numerous statistics. In the series of Wildbolz, of 315 cases, 224 were within these limits; in a series of 70 cases reported by Asakura, 60 were within the same decades; of 70 cases reported from the Massachusetts General Hospital, 58.5 per cent. were from twenty to forty, 61 cases from ten to twenty and but 4 over fifty years of age. It is of interest to note that in the 4 cases over fifty the lesion met with was the occluded, calcareous type of kidney. The condition is rare in childhood (the youngest case in the series being a boy of fourteen), and uncommon in old age.

The frequency of the occurrence of tuberculosis in surgical lesions of the kidney is given by various statistics at about 30 per cent. Kronlein gives tuberculosis the first place in his series, comprising 29.8 per cent. of the surgical cases; Israel puts the number at about one-third. Kuster states that 10 per cent. of all those dying of tuber-

culosis show tuberculous lesions of the kidney. In 20,770 autopsies Kapsammer found 191 cases of renal tuberculosis, or a little less than 1 per cent. The incidence of the disease seems to be somewhat higher in the male than in the female, although statistics differ more or less on this point. In a collection of 1176 cases, reported by von Frisch, Wildbolz, Asakura, Walker, Guillard, Tuffier, Albarran and Braasch, there were 633 males and 543 females. Other statistics give a somewhat higher proportion of females than males, which may account for the statement of Wildbolz that there is a larger proportion of cures in women. The diagnosis certainly presents fewer difficulties in women, and for this reason more cases come to operation. In the early state the disease is unilateral and in the later stage it is bilateral, which accounts for the considerable discrepancy in the percentage of bilateral and unilateral cases reported by various writers. In children the bilateral lesions are more common. Kapsammer reports from his series of 191 cases of renal tuberculosis, 67 were unilateral and 124 bilateral. Also, in the autopsy findings it is not infrequent to find the lesions in one kidney in a much more advanced stage than the other; thereby proving that the disease at one time must have been unilateral. These facts are borne out clinically and are, of course, of the greatest interest and importance in the diagnosis and treatment of tuberculous kidney.

PREDISPOSING CAUSES.

It is a well-known fact that tubercle bacilli are excreted by the kidneys and found in the urine when there is no tuberculosis of the kidneys present. Just why they should be arrested and give rise to the typical lesions in certain cases, and to be allowed to filter through without causing trouble in others, is difficult to explain. Various predisposing conditions have been assigned for this. There are:

1. Hereditary disposition to the disease.
2. Trauma.
3. Renal calculus.
4. Abnormal mobility and stasis.
5. Acute nephritis.
6. Gonorrheal infection.
7. Congenital malformations.

Taking these up consecutively, we find:

Hereditary Disposition.—It is a well-known fact that congenital transmission of tuberculosis is of extremely rare occurrence. Philin and Chalier after an exhaustive study found only 51 authentic cases in literature, in all of which there was a terminal tubercle bacillus bacillemia, with the mother's blood swarming with tubercle bacilli, placental and fetal tuberculosis being present. The fact that renal tuberculosis occurs most commonly between the ages of twenty and forty points decidedly to the disease being acquired. Undoubtedly the hereditary disposition to tuberculosis in general, as evidenced

in a weakened constitution and resistance, plays some part in the incidence of renal tuberculosis, but just in what percentage of cases it is impossible to estimate.

Trauma.—The history of trauma is obtainable in a certain number of cases but is exceedingly unreliable and because of the deep location of the kidneys, of little importance. Experimentally, trauma is undoubtedly a factor in the production of tuberculosis, as well as other inflammatory lesions of the kidney. Clinically, however, the occurrence of tuberculosis in kidneys which have been injured or operated upon (nephrotomy, nephropexy, etc.) shows no relation between these conditions as cause and effect.

Renal Calculus.—Further evidence that trauma is not an essentially causative factor in renal tuberculosis is presented by the literature of renal calculus. While undoubted instances of simultaneous occurrence of renal calculus and renal tuberculosis, and the development of renal tuberculosis in a kidney previously the site of calculus, are found in literature, these conditions are rare. In 256 cases of renal calculus and renal tuberculosis reported from the records of the Massachusetts General Hospital (Crabtree; Cabot and Crabtree), no cases of true calculus were found in tuberculous kidneys as opposed to the calcareous deposits, nor were there any cases of the development of tuberculosis in kidneys from which calculi had been removed. There can be no doubt that the trauma produced by a calculus is quite sufficient to invite tuberculous infection, were trauma any considerable factor in the etiology.

Abnormal Mobility and Stasis.—Theoretically it would seem as if the faulty drainage and interference with the circulation produced by a movable kidney would tend to cause the arrest of the tubercle bacilli. The percentage of movable, tuberculous kidneys, however, is, according to Kuster, only 5 per cent. Furthermore, the percentage of movable kidneys is much higher in women than men, whereas the occurrence of renal tuberculosis is but slightly so. It is also very difficult in any given case of renal tuberculosis to determine whether the amount of hydronephrosis present is due to any previous obstruction or is the result of the tuberculous process alone.

Acute Nephritis.—This being a condition which is diagnosed clinically, when the acute process is followed by a tuberculosis, its advocates must be able to show that the primary and acute onset was not of tuberculous origin.

Gonorrheal Pyelitis.—This is an unusual condition clinically, and can play no very important part in the causation of renal tuberculosis. However, that the occasional insidious transformation from a gonorrheal to a tuberculous process may occur, cannot be denied.

Congenital Malformations.—Misplaced and abnormally developed kidneys are undoubtedly predisposed to tuberculous infections, as well as to other renal lesions. It is here again logical to expect that the abnormal position would tend to cause the arrest of the bacilli in the

blood stream. This is borne out clinically by the fact that when renal tuberculosis is met with in a person with some such abnormality, the disease is found in the abnormal organ. The writer has had a personal experience in meeting at operation with tuberculosis in a horseshoe kidney.

Routes by which the Tubercle Bacilli Reach the Kidney.—The tubercle bacilli may reach the kidney by means of the blood stream, through the lymphatic channels or by direct extension.

The old belief that infection of the kidney took place by direct extension ascending through the lumen of the ureter is now entirely discredited. It was based principally upon the fact that the symptoms in a large majority of cases pointed to the bladder as the primary focus. Also, experimentally this avenue of infection has been proved possible when there is obstruction of the urinary flow. The conclusions of Bauereisen are here of interest as summing up the experimental work. He states: (1) A bladder with intact mucosa cannot be infected with tuberculosis. (2) With the flow of urine unhindered tubercle bacilli cannot reach the kidney intra-ureterally. (3) Obstruction of the urinary stream will, as a rule, result in ascending urogenous infection of the kidney. Clinically, however, this must occur rarely, if ever.

Hematogenous Infection.—There is ample evidence to show that the bacilli are carried to the kidney by the arterial blood in a great majority of cases. Blood infections in tuberculous patients are not uncommon, and it is a well-established fact that even with a small tuberculous focus in an active state, such as an apical lesion, there may be a temporary bacillemia during which time the bacilli may be recovered from the blood. Further evidence that tubercle bacilli reach the kidney more or less constantly is shown by numerous observations, that in pulmonary tuberculosis a filtration of bacteria may take place through the kidneys which after death show no evidence of tuberculous disease.

Also, clinically it is a well-known fact that tuberculosis occurs frequently without involvement of the bladder, and independent of any other tuberculous lesion in the urinary tract.

Lymphatic Infection.—Next to the blood stream as a route of infection the lymphatics deserve the most consideration. There are objections in the pathology to the belief that all infections are from the blood. A typical hematogenous infection begins with the miliary tubercle. A certain number of cases are found at an early stage with ulceration beginning in the pelvis and along the portion of the papilla which projects into the pelvis. It is difficult to see how this can be hematogenous and this is the part of the kidney most likely to be involved in lymphatic infection. However, upon the advocates of this theory rests the burden of proving by serial sections of all papillæ that there are no small cortical lesions or lesions of the papillæ.

Brongersma is a strong advocate of the lymphatic route, and believes that infection takes place from the mediastinal glands in cases of pulmonary tuberculosis. He has demonstrated at autopsy, tuberculosis

PLATE VI

Acute Hematogenous Infection of Kidney.

Organ bisected, showing anterior and posterior surfaces. (Lumière Photograph.) (Brewer.)

of the apex of the lung, with tuberculosis of the glands extending along the aorta through the diaphragm to the neighborhood of the kidney on the same side. In this way he accounts for the fact that renal tuberculosis is unilateral in the early stage. There is unmistakable evidence to show that instances of infection traveling to the kidney from the peritoneum and pleural cavities have occured.

Ascending infection from a process in the bladder and genitals to the kidney by way of the lymphatics in the walls of the ureter which communicates through the retroperitoneal lymph nodes is more than a possibility. The recent work of Sweet and Stewart is of great interest in this connection. They have demonstrated in non-tuberculous infections the occurrence of pyelonephritis from bladder infections when the ureteral wall was left intact, but they failed to get the infection when the ureter was divided and the lumen made continuous by a piece of rubber tubing. The objection to this theory in tuberculosis is that tubercles are not usually found in the para-ureteral tissue, that the lesion is chiefly of the mucosa extending into the muscularis.

Aside from playing a part in bringing infection to the kidney, the lymphatics may be factors in spreading tuberculosis in the kidney after infection. This will be discussed later under ascending infections within the kidney.

Direct Extension.—The kidney may be involved by direct extension from neighboring organs as in caries of the spine, disease of the adrenal gland or the bowel. Here, however, the portion of the kidney adjacent to the infecting organ is involved in a sclerotuberculous mass and the picture is readily distinguished from the ordinary type.

The great preponderance of evidence and the almost universal belief today is that the hematogenous route of infection is by far the most common.

PATHOLOGY OF TUBERCULOSIS OF KIDNEY AND URETER.

BY E. GRANVILLE CRABTREE, M.D.

Tubercle bacilli reach the kidney by way of the blood stream in a vast majority of the cases. It cannot be denied that ascending infection within the lumen of the ureter, where there is damage to the ureterovesical opening, infection by way of lymphatics without the intervention of the blood, and direct extension from neighboring tuberculous organs may result in kidney infection. Extension tuberculosis from adrenal gland, caries of the spine, tuberculosis of the large intestine, etc., is readily recognized pathologically by the sclerotuberculous tissue connecting the two organs. There is nothing in the pathological picture by which it is possible to determine with certainty that a tuberculous process in the kidney is the result of an ascending infection. The possibility of blood-borne or lymphatic infection always exists. In a few cases direct extension from the pleura to the

kidney by way of the lymphatics has been demonstrated by Brongersma by means of pigmented glands, yet there is nothing in the type of kidney lesion produced to distinguish lymph-borne infection, and the number of cases in which the path could be demonstrated is extremely small. The occurrence of tuberculosis of the kidney in the decades between twenty and forty rather than in infancy, and the high percentage of the human type as distinct from the bovine type of bacilli discredits extension from the peritoneum.

The number of bacilli reaching the kidney and local resistance of kidney tissue probably determine the production of acute or chronic tuberculosis, or the ability of the kidney to excrete the bacilli without itself becoming infected.

Initial Lesion.—The site of the initial lesion in renal tissue cannot be stated with certainty. Pathological and experimental evidence clearly shows that tubercle bacillus-laden emboli lodge at the common site of primary tuberculous foci, namely, the region between cortex and medulla somewhere in the base of a pyramid, while certainly the mode of infection in some cases is not the common way in which these lesions are produced. The evidence produced leads me to accept the following explanation of the findings in tuberculosis of the kidney.

Most of the bacilli which reach the kidney through the renal artery are arrested in glomeruli. Undoubtedly some few escape from the capillaries of the glomerulus by the efferent blood stream and may be arrested in the complex venous channels which surround the tubules and descend with them toward the pelvis. It is also possible that they may lodge in the interstitial tissues in arterioles which supply this area directly from the renal artery. In the miliary form of the disease pathological changes quickly follow the arrest of bacilli, and the lesions are cortical, most numerous in the glomeruli. In patients who have long harbored a tuberculous process, the kidney may have acquired sufficient resistance to the bacilli to allow of excretion of tubercle bacilli without resulting pathological change. Chronic tuberculosis is evidently a mean between these extremes.

If glomerular lesions are produced in chronic renal tuberculosis they either become sclerosed or are small and overshadowed by more rapidly growing lesions in the tubular regions. Tubercle bacilli in some way perforate the capillaries of the glomerulus, reach the capsule of Bowman and enter the lumen of the tubule. Stained sections show that the bacilli are most likely to be arrested in the convoluted tubules where the stream is broadened and the epithelial cells are probably phagocytic (Fig. 187).

The tissue changes incited by the presence of the tubercle bacillus in kidney tissue are endothelial-cell proliferation, proliferation of epithelial cells of the tubules and round-cell (lymphocyte) infiltration. Observers are at variance as to whether endothelial-cell changes or epithelial proliferation is primary. Round-cell infiltration is certainly of minor importance and does not take place in some of the lower

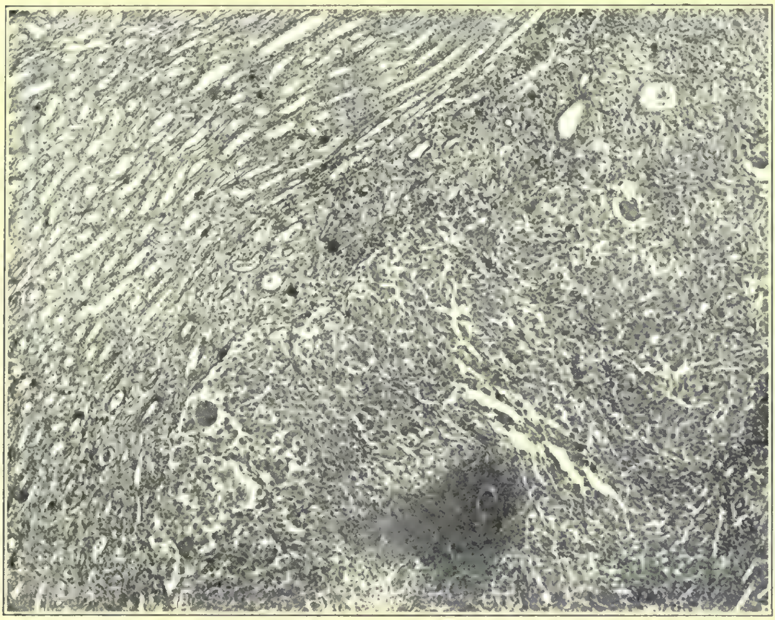

FIG. 187.—Edge of tubercle of excretory origin in pyramid in rabbit kidney produced experimentally.

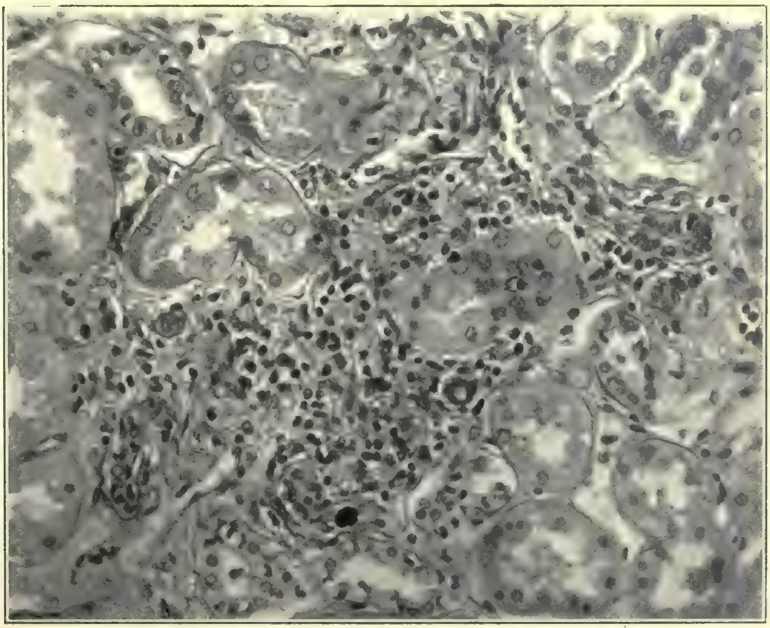

FIG. 188.—Young tubercle in proximal convoluted tubule beneath one of cortical lesions shown in Fig. 192. Note hyperplasia of renal epithelium, and endothelial and round-cell infiltration.

animals. I have frequently observed tubercles in which epithelial proliferation was apparently primary where the lesion was of the convoluted tubule (Fig. 188).

Tissue destruction or erosion begins at the centre of the tubercle as a result of the action on the protective cells of toxins produced by the tubercle bacillus. The first change is fat formation in the injured cells nearest the centre with subsequent death and disintegration of the fatty cells. Tubercle bacilli are found most abundant at the edge of the area of caseation.

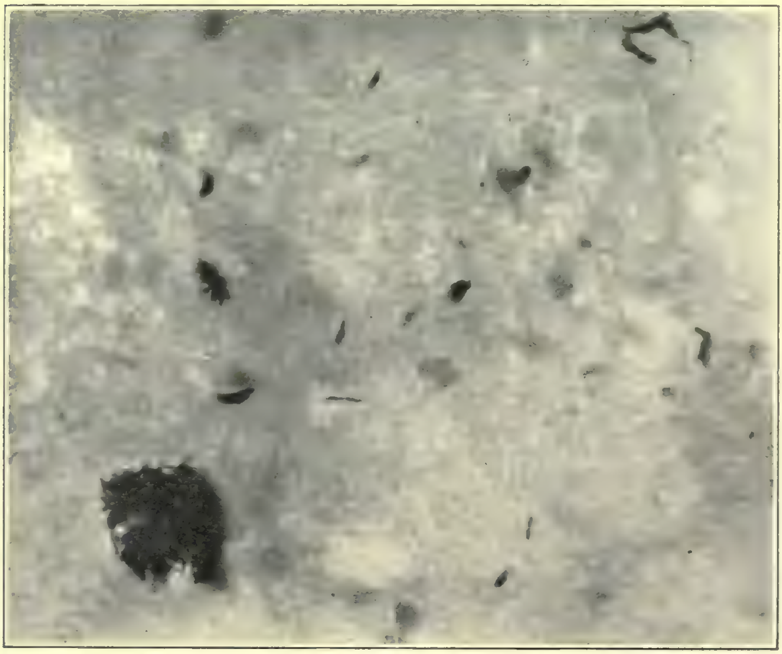

FIG. 189.—Tubercle bacilli growing in a recess of the pelvis of an early case of renal tuberculosis. Tubercle bacilli stained in sections from region of pyramids at a point remote from the primary focus of infection in the kidney.

Spread of the Disease within the Kidney.—By tissue destruction infection spreads in all directions within the lobule of the kidney containing the primary focus but extends most rapidly along the course of the tubules until finally it breaks through into a calyx either at the tip or along the side of a papilla. This leads to infection of the calyx from which infection spreads to all parts of the renal pelvis, producing a tuberculous pyelitis. The tubercle bacilli multiply in the recesses of calices (Figs. 189 and 190), attack and ulcerate the walls of the neighboring papillæ (Fig. 191). Infection may then spread back into the kidney tissue from any part of the pelvis and the whole of the kidney become infected. Ekehorn has shown by serial sections of all the

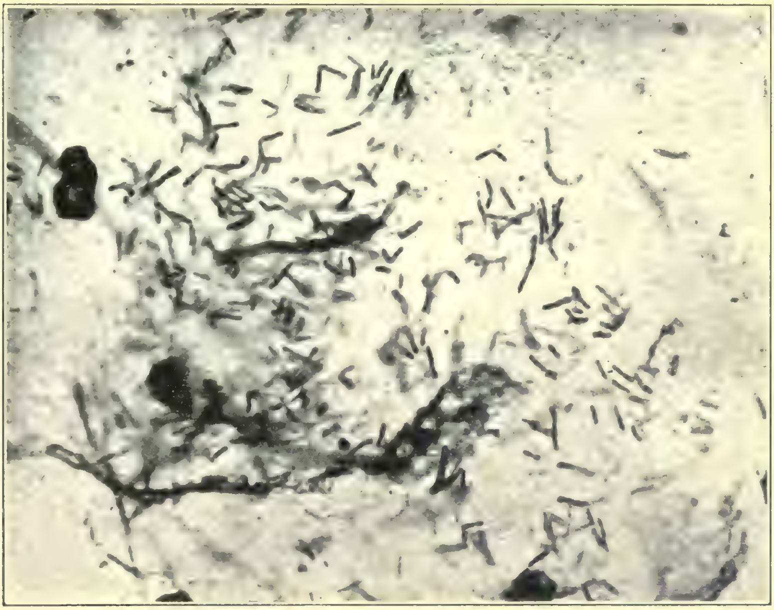

FIG. 190.—Tubercle bacilli in smear from calyx in early case of tuberculosis of kidney in which symptoms were very severe and secondary lesions of the bladder were numerous. There is extensive tuberculous pyelitis. Diagnosis by centrifuge easily made in this case.

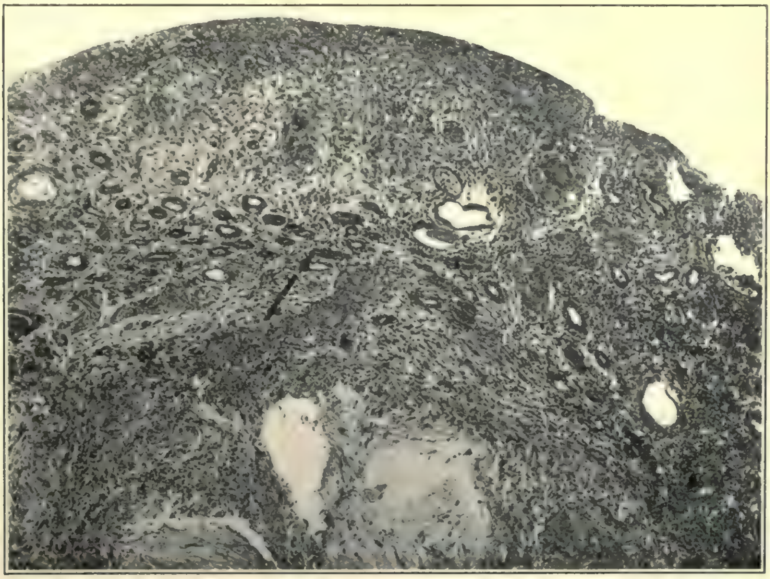

FIG. 191.—Beginning involvement of a pyramid from tuberculous pyelitis in an extensively involved kidney. Primary lesion in opposite pole of kidney. Note tubercles in tip with caseated lesion above and general infiltration of the tissue.

papillæ projecting into infected pelves that once there is a tuberculous pyelitis, no papillæ escape infection. Tubercle bacilli are carried back into the kidney tissue along the lines of the tubules apparently by way of the lymphatics. These secondary infections are apt to extend in the interstitial tissues as fine lines of tuberculous infiltration, which are usually independent of glomeruli, beyond the convoluted tubules, past glomeruli, to end in cortical lesions just beneath the capsule. This extension of the process could not have taken place by way of the lumen of the tubule without being limited by the glomerulus and must have resulted through transmission of bacilli either by way of the blood stream or by way of the lymph channels. Inasmuch as by far the greater portion of the blood supply of the kidney comes by way of the glomerulus and follows closely the downward course of the tubule to reach the renal vein, it is more probable that the tubercle bacilli reascend to the cortex by way of lymph channels.

FIG. 192.—Subcapsular lesions in apparently normal renal tissue remote from a single primary nodule in the base of a pyramid in the opposite pole. These two are from a series. Note that they take origin independently of glomeruli and are just beneath the capsule.

Capsule.—There is considerable evidence to indicate that in addition to the ascending infection within the kidney which has just been described, infection is disseminated through the lymph channels of the capsule. In active early lesions of one pole of a kidney examination of the cortex of remote and apparently perfectly normal portions of the kidney reveal rows of small tubercles situated just beneath the true capsule, invariably not originating in glomeruli and overlying tissue which is entirely normal (Fig. 192). No lines of tuberculous tissue

such as is associated with the cortical tubercles which overlie the primary focus can be demonstrated to run between the process at the tip of the pyramid and these cortical tubules. Extension of infection through the lymphatics of the capsule explains the occurrence of small cortical lesions in the second portion of the double kidney and the other half of the horseshoe kidney. These lymph-borne tubercles seem to be secondary processes and not significant in accomplishing the destruction of the kidney. They are frequently found to be sclerosed. They may explain the failure of partial nephrectomy for tuberculosis and the uniformly poor results of operations on horseshoe kidneys where one-half of the kidney is involved in a tuberculous process.

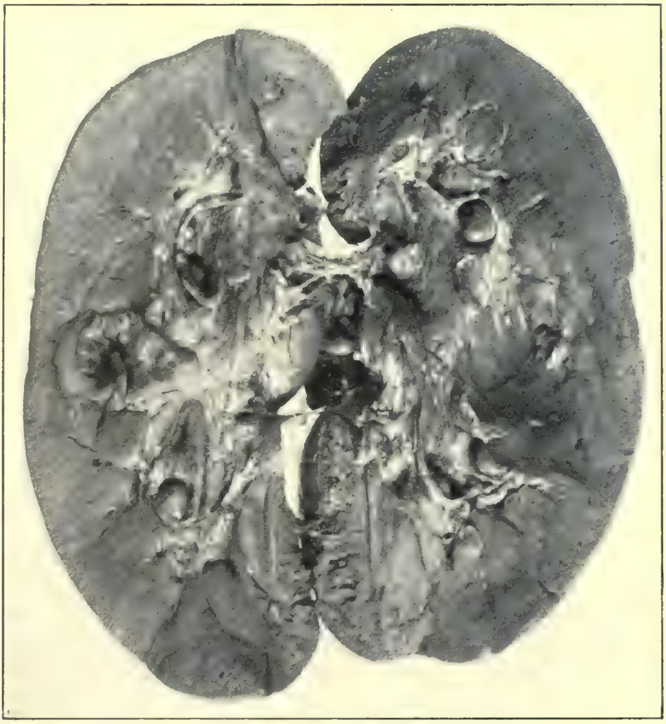

FIG. 193.—Kidney showing early lesion, with ulcerative lesion involving base of one pyramid only. Also tuberculous lesions of the pelvis. (Massachusetts General Hospital.)

Descriptions of Lesions.—Acute Tuberculosis.—Acute tuberculosis is but a part of a general miliary process. It is always bilateral, rapidly progressive, fatal and not a surgical condition. The kidneys when seen at autopsy are slightly enlarged, purplish colored, and studded with many cortical abscesses. Churchman is authority for the statement that tubercle bacilli appear in the urine in this form of the disease before they appear in any of the other body excretions. In the

limited number of examinations made, I have not failed to find tubercle bacilli in the urine of these cases.

A subacute form of tuberculosis, the description of which is accredited to Pousson, is very rarely seen. The pathological picture is that of a diffuse tuberculous nephritis without tubercle formation. The condition is usually bilateral and always rapidly fatal.

Surgical (Chronic) Tuberculosis.—Chronic tuberculosis of the kidney is a progressive disease. Kidneys seen at autopsy and operation present various stages in the progress of the disease from a single ulcerative lesion not yet reaching the pelvis to complete destruction of the kidney.

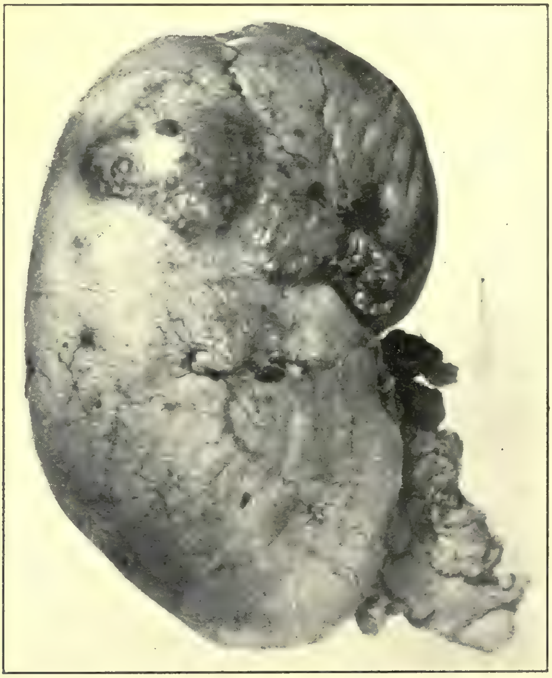

FIG. 194.—Extensive cortical tuberculosis of upper pole of the kidney. Kidney was of about normal size. (Massachusetts General Hospital.)

Early Lesions.—The earliest lesions found at operation—early in regard to extent of damage done, not necessarily in regard to the time of their existence—are usually in normal-sized kidneys with smooth outline, and often with no evidence of cortical disease (Fig. 193). The cut surface is apt to show a single tuberculous cavity situated in a pyramid, such a lesion being commonest at one or the other pole of the kidney. The cavity contains thin flaky pus and presents a shaggy surface. The pelvic mucosa is roughened, has lost its sheen and may present ulcerations particularly on the lateral surfaces of papillæ. The pelvic wall and ureter are thickened. The greater portion of the

kidney cortex appears normal, yet microscopic examination may reveal the presence of small tubercles beneath the capsule in any portion of the kidney.

The Ulcerocavernous Type.—The ulcerocavernous type of renal tuberculosis is a more advanced stage in the destruction of the kidney (Figs. 194, 195, 196 and 197). The kidney is usually enlarged to one and one-half or twice the normal size, reddish and occasionally showing groups of cortical tubercles just beneath the capsule and connected with the main process by fine lines of infiltration. The cut surface

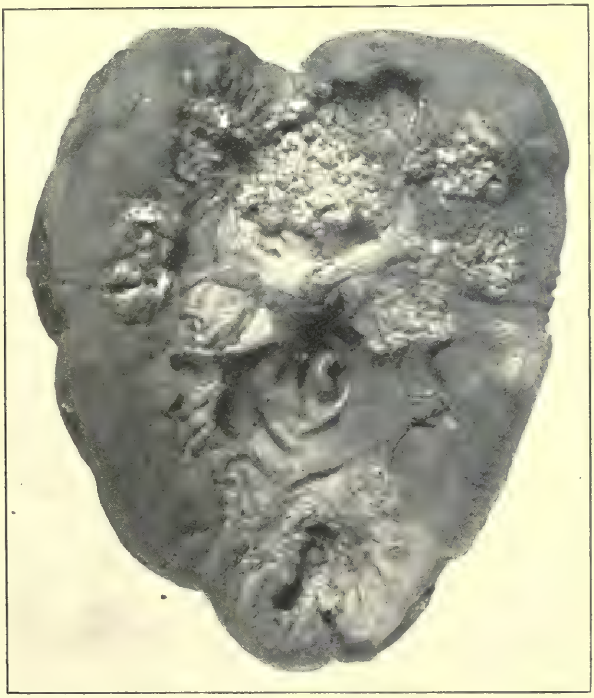

FIG. 195.—Section of same kidney, showing extensive ulcerative lesions of upper pole and single ulcer of lower pole. (Massachusetts General Hospital.)

shows extensive ulceration of the papillæ involving the pole of the kidney in which the lesions are oldest, while the remainder of the papillæ are involved in more recent ulcerative processes. The cavities are sometimes deep yellow in color, due to the presence of fat. The cortex of the kidney above the ulcers may appear normal or may show fine lines of tubercles extending from the ulceration to end in a mass of cortical tubercles. Where cortical tuberculosis exists, there are apt to be extensive adhesions of the fatty capsule. Adhesions are also quite common about the renal pelvis.

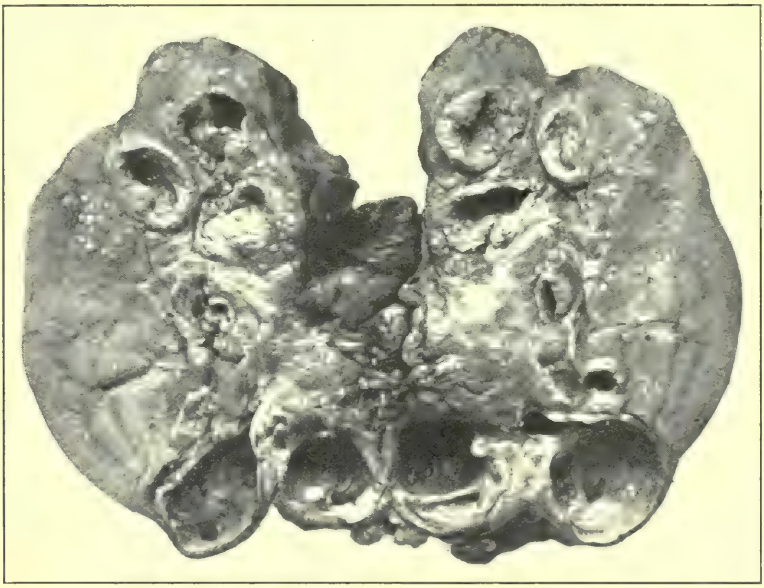

FIG. 196.—This specimen shows the lower pole to be the site of an old process. The cysts were walled off, containing clear fluid, and illustrating nature's attempt at a cure. The upper pole shows several recent abscess cavities. The renal tissue in the middle of the specimen shows in its lower part the normal markings of the kidney; in the upper part these have disappeared and the deposit of tubercles is well shown.

FIG. 197.—Kidney showing extensive ulcerative processes of all the pyramids with extensive fatty changes about the cavities. (Massachusetts General Hospital.)

Tuberculous Pyonephrosis.—The advent of obstruction to the outflow of pus and urine in any stage of the disease gives rise to pelvic dilatation and distention of the kidney—tuberculous pyonephrosis (Figs. 198, 199, 200 and 201). These kidneys are usually considerably enlarged, lobulated, and rounded. On cut surface the cortex is thinned, sometimes studded with tubercles and its calyces dilated. Obstruction is commonest in late stages of the disease. It is not uncommon to

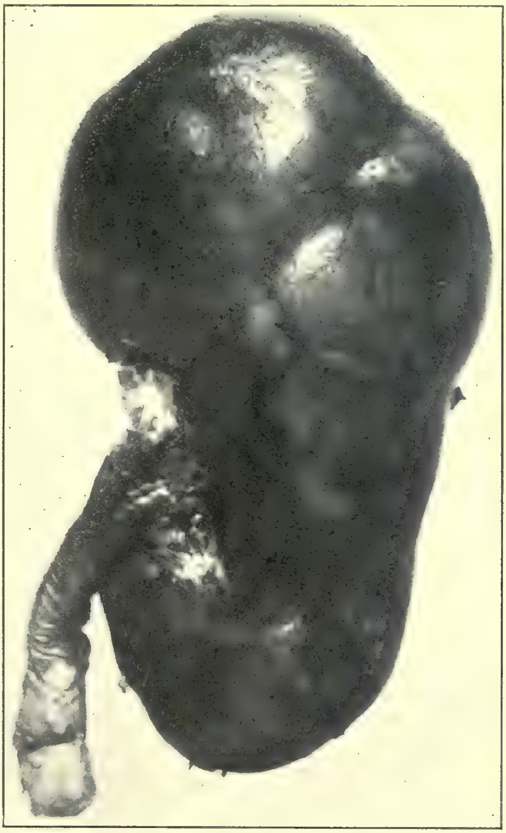

Fig. 198.—Enlarged bossed kidney, showing thickened ureter. (Massachusetts General Hospital.)

find the greater portion of the kidney occupied by distinct rough-walled cavities conforming in shape to kidney divisions, renculi, and filled with thin, flaky to thick, non-odorous, creamy pus. In still other kidneys one portion may show extensive cavity formation while the remainder is involved in a much more recent process in the stage of early caseation but associated with ureteral obstruction and extensive pelvic dilatation.

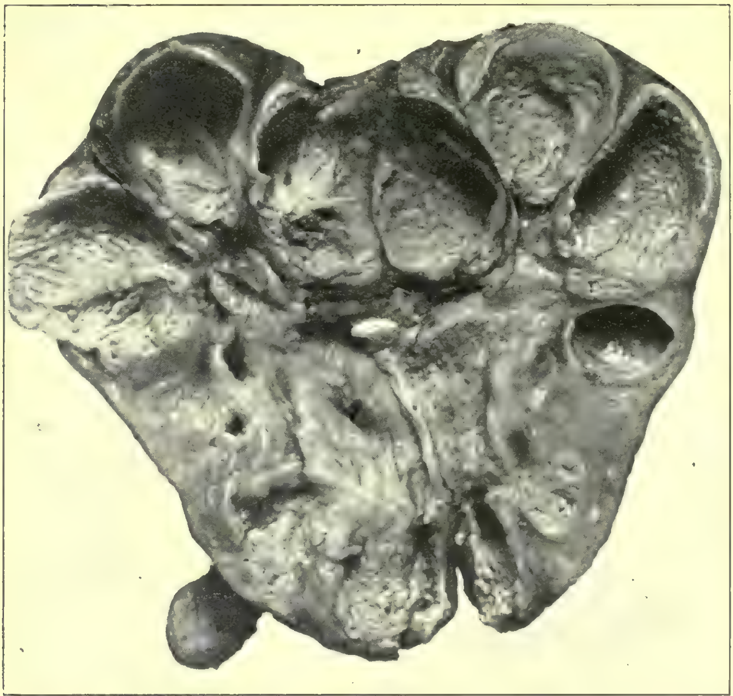

FIG. 199.—Section of Fig. 198, showing complete destruction of the upper half of the kidney with ulcerations of the lower pole. (Massachusetts General Hospital.)

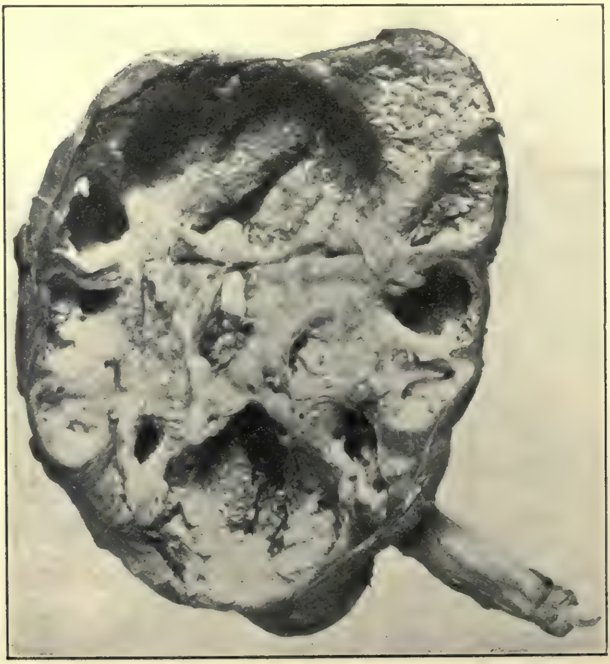

FIG. 200.—Tuberculous pyonephrosis with complete destruction of the kidney.

Obstruction to outflow from the tuberculous kidney is commonly attributed to tuberculous stricture of the ureter. Undoubtedly this is the commonest factor encountered. Pelvic retention without any evidence of narrowing of the lumen of the pelvis or ureter is a frequent occurrence. Apparently as a result of the disease the walls of the pelvis and ureter become lax, dilate and the pelvis becomes distended. At

Fig. 201.—Tuberculous pyonephrosis with fragments of thickened fatty capsule. (Massachusetts General Hospital.)

autopsy the pelvis is found distended and the ureter dilated to several times its normal size throughout its length. Loss of tone and normal muscular activity of pelvis and ureter seem sufficient cause in some cases for the production of pyonephrosis.

Autonephrectomy.—A still more advanced type of tuberculous lesion is the caseated or completely destroyed kidney (Fig. 202). It is the stage of the disease referred to clinically as autonephrectomy. The

tuberculous process has reached the stage of complete destruction of all kidney tissue. Often the contents of the ulcerations becomes inspissated or impregnated with calcium salts, producing a soft white putty-like mass which occupies the site of the previous ulcer. In less advanced stages of the disease the process of calcification may have taken place in only a few of the ulcerated areas, while others show yellowish, thick, inspissated pus not yet calcified.

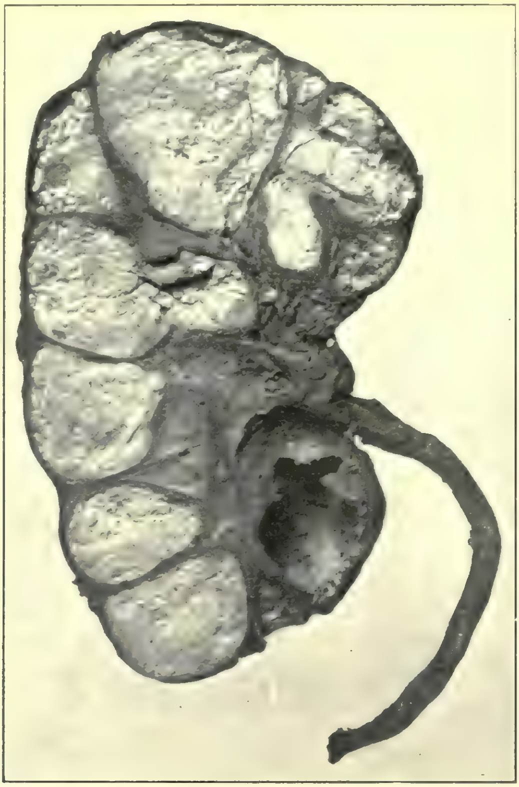

FIG. 202.—Autonephrectomy with complete destruction of the kidney by caseation with calcification. (Massachusetts General Hospital.)

There is considerable evidence to indicate that the tubercle bacillus is present in calcified kidneys. Apparently completely destroyed kidneys have been known to act as foci from which a miliary process results.

Sclerous Tuberculosis.—In a few rare instances attempts at healing have resulted in extensive scar-tissue formation throughout the kidney. The kidneys are contracted, adherent to the fatty capsule, and on cut surface present a smooth, firm tissue, with several active tuberculous ulcers, usually of small size (Fig. 203).

Tuberculosis in Abnormal Kidneys.—The progress of the disease in abnormal kidneys shows certain existing departures from the previous descriptions. In horseshoe kidneys only the pelvis into which the primary focus has extended is found infected in early cases, while the pelvis of the other half of the kidney is entirely free. In most cases cortical tubercles apparently from extension by way of lymphatics of the capsule can be demonstrated in the second kidney. In double kidneys the same facts are often observed, that is, a tuberculous pyelitis of the diseased kidney with no evidence of infection of the other half

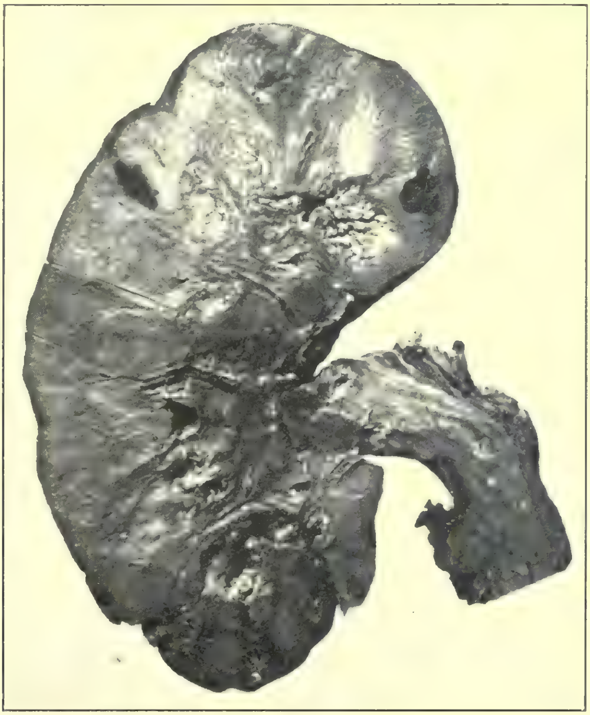

FIG. 203.—Kidney showing autonephrectomy with occlusion of ureter but without pyonephrosis. Microscopic examination shows extensive fibrous tissue changes along with caseation. (Massachusetts General Hospital.)

save the presence of minute cortical tubercles. The progress of the disease has resulted in destruction of the kidney tissue draining into the infected pelvis. The ureter from the infected pelvis shows thickening and that from the uninfected, none. In still other kidneys a portion of the pelvis early becomes walled off by the formation of a partition composed chiefly of fat and fibrous tissue, and the disease progresses within that portion of the kidney but the remainder of the pelvis remains free for a time. Occasionally at the autopsy table or by accident in surgery, a kidney is found in which the tuberculous process is

still confined within the kidney tissue and has not yet infected the pelvis (Fig. 204). These cases are only found by accident, since the diagnosis of tuberculosis of the kidney is only made by the demonstration of a tuberculous pyelitis.

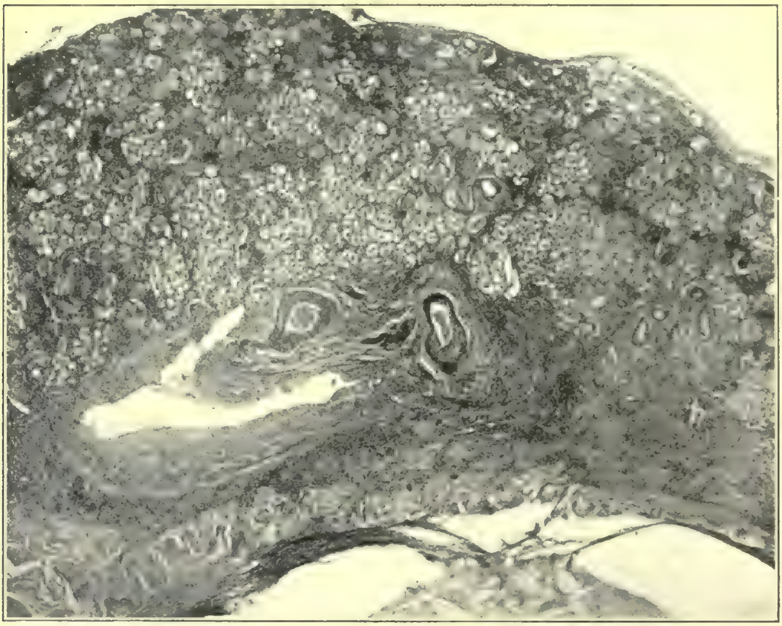

Fig. 204.—Tuberculosis in abnormally developed kidney. Edge of cystic area seen at lower edge of field without connection with pelvis. Atrophic and sclerosed glomeruli, dilated tubules and two foci of tuberculosis are seen.

Caseation (Fig. 202).—Caseation in tuberculosis is a remote result of the toxins produced by the bacilli. The toxins produce injury to the cells which results in fatty changes followed by death and disintegration and the liberation of cell detritus and the contained fat into the caseating area. Sections of small tubercles stained with Sudan show fat globules within the injured endothelial cells and giant cells at the periphery, and considerable fat throughout the centre of the areas of caseation. As a result of necrosis and injury to the blood supply there is stasis, poor absorption and imperfect oxidation in the region of caseated areas, a condition which leads to deposit of calcium salts from the blood stream. In old tubercles the fats are broken up into fatty acids which soon combine with calcium to form calcium soaps. Chemists believe that the soaps are later changed into less soluble phosphates and carbonates of calcium.

Toxic Nephritis.—A long-standing tuberculous process in one kidney may lead to damage of the opposite kidney, the so-called toxic nephritis. In one class of cases, the urine shows a simple albuminuria without

pus, epithelial cells or casts. Microscopic sections of these kidneys show no cell changes. This is probably a purely functional derangement like orthostatic albuminuria. In other cases there is a desquamation of epithelium of the tubules with cell casts. These kidneys apparently are little damaged and seem to go on to recovery after removal of the diseased fellow. There is a final group in which the process in the diseased kidney is of long-standing where the opposite kidney shows evidence of a parenchymatous nephritis.

Healed Tuberculosis.—There has never yet been produced a kidney which on pathological examination shows evidence of a completely healed tuberculous process. There is often seen in tuberculosis of the kidney, areas of almost complete sclerization, circular in outline, evidently an old tubercle, the centre of which is occupied by a few endothelioid and round cells. There is also a scirrhous type of renal lesion in which the kidney tissue is firm and microscopic section shows extensive fibrous tissue change. Foci of tuberculosis in the active stage can always be demonstrated in some portion of such a kidney.

Pathological findings give no encouragement to partial nephrectomy as an operative procedure. Early caseated lesions of the substance of the kidney which have not yet invaded the pelvis are sometimes discovered by accident, and since diagnosis cannot be made, do not come within the field of operative surgery. Conclusive evidence is produced to indicate that in the typical tuberculous kidney, no matter how small the primary focus, a tuberculous pyelitis exists with infection of all the pyramids as well as subcortical extension to remote parts of the kidney. Although, macroscopically, a limited lesion exists, a tuberculous kidney must be considered to be infected throughout its whole. In the rare cases of walled-off portions of a kidney pelvis, total extirpation of the kidney is demanded for cure since microscopic subcapsular extension is almost always present. These minute lesions are sufficient to accomplish, eventually, the destruction of the remainder of the kidney.

Perinephritic Abscess.—Extension of the pyogenic process through the true capsule to involve the perinephric fat constitutes perinephritic abscess. In our experience the condition has occurred in association with the pyonephrotic stage of the disease and with mixed infection of the tubercle bacillus and pyogenic organisms.

Tuberculosis of the Pelvis, Ureter and Bladder.—Tuberculosis of the pelvis, ureter and bladder are secondary to the primary focus in the kidney tissue. The lesions belong to what are known clinically as "secondary" lesions and show a tendency to heal promptly when the original source of infection in the kidney is removed. Except in rare cases where a portion of the pelvis becomes walled off early in the disease a tuberculous lesion in the kidney always results in an infection of the whole of the pelvis. The lesions in the pelvis are chiefly of the submucosa, and appear microscopically as endothelioid and round-cell infiltration with some definite tubercle formation apparently

originating beneath the epithelium from where extension into the deeper layers and through the epithelial layers takes place. The epithelial layer above a tubercle in the submucosa becomes necrotic from malnutrition and an ulcer is produced. Tubercle bacilli growing in recesses of calyces seems capable of producing necrosis of the epithelium of the calyx. Primary ulcerations of the pelvis without any disease of the kidney have been reported by Buerger. He, however, records no microscopic examination of the kidney tissue. In late stages of the disease the peripelvic fat is extensively involved in the tuberculous process, producing many adhesions of the fatty capsule.

FIG. 205.—Round- and endothelioid-cell infiltration of ureter without tubercle formation. Note that infiltration is chiefly of submucosa. From an extensive lesion of the kidney.

Tuberculosis of the ureter is secondary to that of the pelvis. Infection is by contiguity and probably always extends in the submucosa. The lesions are infiltration with round and endothelial cells or definite tubercle formation (Figs. 205 and 206). Ulceration of the epithelium takes place. Extension of the process into the muscularis and serous coats follows, giving a much thickened, dilated and adherent ureter. Tuberculosis of the upper and lower thirds of the ureter with comparative free middle portion is common. Scar-tissue formation from healed lesions may produce narrowing of the lumen or stricture.

Tuberculosis of the bladder appears first about the orifice of the ureter from the diseased kidney. The lesions spread by contiguity

in the submucosa. Bladder lesions show a marked tendency to heal, and tubercles with intact mucosa covering them, ulcers, and cicatrices may be found in the same bladder.

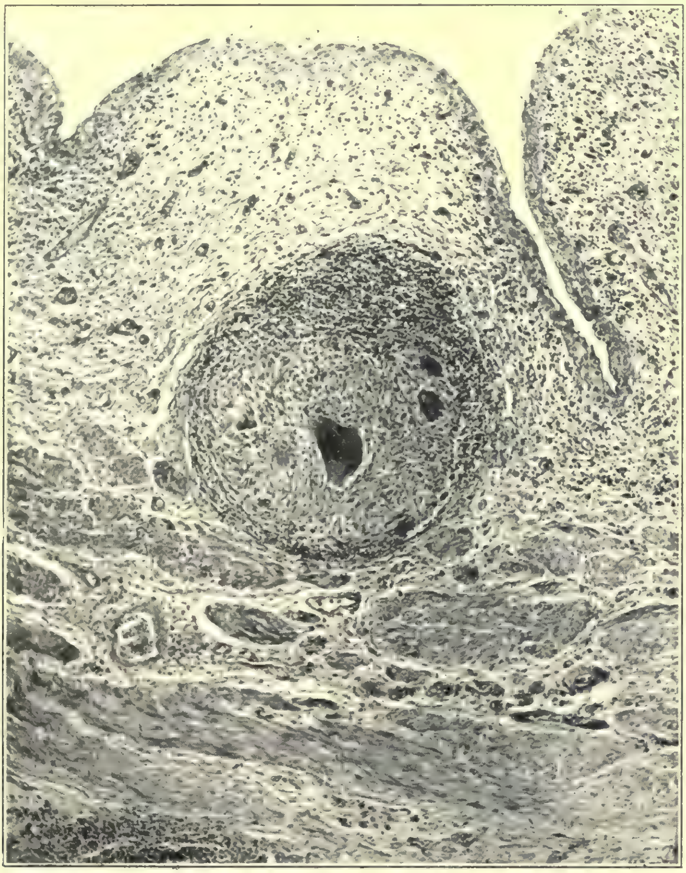

FIG. 206.—Tuberculosis of ureter with tubercle formation. Note location of tubercles in submucosa and infiltration of submucous tissue extending out into the muscularis and ulceration of mucosa. Ureter from an early case of tuberculosis.

PHYSICAL AND GENERAL EXAMINATION AND HISTORY.

The family history of tuberculosis or exposure to the disease in persons presenting urinary symptoms, may be suggestive of urinary tuberculosis, but its absence is of no importance and in the majority of cases such a history is unobtainable. The personal history of any tuberculous process is of great importance, and careful inquiry should be made as to a preëxisting pleurisy, continued cough, bone sinuses, joint trouble or glandular swellings. The lungs should be carefully examined by an expert, to determine the presence of an active process

or signs of latent or healed areas. The physical examination should include a search for scars, particularly in the neck, over the long bones and in the neighborhood of joints. In the latter, any swelling, limitation of motion, or ankylosis should arouse suspicion. An examination of the spine should be made for deformity or limitation of motion, as a psoas abscess forming in the loin may simulate one of perirenal origin.

Palpation.—Abdominal palpation is frequently negative, as tuberculous kidneys in the early stage are no more palpable than normal kidneys. Palpation on the other hand may be very misleading. One kidney may be felt to be slightly enlarged and slightly tender; such a kidney is by no means to be considered as the diseased one, as ureter catheterization often shows the palpable kidney to be the healthy organ, the increase in size and tenderness being due to the compensatory hypertrophy. In the late stages the kidney may become distinctly enlarged and irregular from pyonephrosis. Also, if much perinephritis or a perinephritic abscess is present, a resisting mass in the loin is to be made out. At times, however, the diseased kidney becomes a small, shrivelled organ which cannot be felt, the palpable kidney being the hypertrophied normal one. Diagnosis by palpation should never be made without the confirmatory evidence of cystoscopy.

A thickened, tuberculous ureter may at times be felt in the abdomen in thin subjects, as a cord just above the pelvic brim. The lower end may be felt by vagina in the female. In the male, palpation of the testes, epididymes and vasa should be supplemented by a rectal examination to ascertain the condition of the prostate and seminal vesicles. The lower end of a thickened, tuberculous ureter may occasionally be felt during this procedure. In the presence of a tuberculous genital focus in the male, one should always have in mind the possibility of renal involvement as well.

Loss of Weight.—In bilateral and advanced cases, loss of weight, pain, lassitude and weakness are often to be seen, sometimes to a marked extent. In the early stages, however, the general appearance and color may be excellent, there being no loss of weight; in fact we recall several patients who were distinctly fat.

Temperature.—Temperature may be entirely absent, although a number of cases run a moderate, irregular fever, fluctuating from normal to 100°. When obstruction or mixed infection is present, the fever is high, going to 102° or 103°. The typical up-and-down tuberculous temperature is seldom observed. There is generally some increase in the pulse rate.

SYMPTOMATOLOGY AND DIAGNOSIS OF TUBERCULOSIS OF KIDNEY AND URETER.

The actual pathological lesions in the kidneys always antedate the appearance of the clinical symptoms, sometimes for a period of months, or even years. It is not uncommon in the so-called early

cases (by that is meant the cases which are operated on early after the occurrence of symptoms) to find quite an extensive destructive lesion in the kidney which has but recently ruptured into the pelvis. Symptoms are not observed until the lesions connect in some way with the urinary passages.

Frequent Micturition.—By far the most common of the early symptoms of renal tuberculosis, and the one for which the patient most often seeks relief, is that of vesical irritability. This first shows itself as a gradually increasing frequency of micturition. The onset is insidious and at first the frequency is confined to the day, later on, the demands to micturate become more frequent and urgent and nocturia supervenes. As the case advances the intervals between micturitions become shorter and the patient may be obliged to void every hour or half-hour, day and night. In severe cases there is incontinence, especially at night. In children incontinence and enuresis may be the presenting symptom. The symptoms at first are due simply to the presence of an irritating urine in the bladder coming from the affected kidney, later on, when actual secondary involvement of the bladder mucous membranes occurs, urgency, and pain at the end of micturition are added. Micturition is associated with pain along the urethra, generally of a burning character, and often localized in the posterior urethra.

In some cases the symptoms are those of a cystitis during the entire course of the disease, there being at no time any symptoms referable to the kidney.

Hematuria.—Hematuria is occasionally a very early, and may be for a time the only symptom. It is very apt to be slight and transient and the patient may be lulled into a false sense of security by its disappearance. Unfortunately, not infrequently the physician, if consulted at this time, fails to attach due importance to this symptom. In other cases the bleeding may be severe, sufficiently so as to demand operation. The interval between the primary bleeding and the occurrence of other symptoms may be considerable. Thompson Walker mentions a case in which it was two years. With the secondary bladder involvement there is generally terminal hematuria, and microscopic blood is almost always to be found. Hematuria on the whole is a variable symptom and may be present during any stage of the disease.

Pain.—Pain may be entirely absent, the kidney becoming completely destroyed without any pain being felt in or referred to it. In our series at the Massachusetts General Hospital, pain in the affected kidney was second in the list of presenting symptoms and was present in 35.7 per cent. In general the type of pain, whether occurring as a presenting symptom or during the course of the disease, is of a dull, aching character, either at the costovertebral angle or indefinitely located in the loin on the affected side. In some cases, particularly those with hemorrhage, the pain is of a colicky nature along the ureter,

from the passage of clots and detritus, and is similar to that of renal calculus. In the types where there is obstruction of the ureter and pyonephrosis, pain in the loin is a more constant symptom. Mixed infection and perinephritis are also factors in the causation of pain.

Bladder pain is in close relation to other vesical symptoms, as frequency and tenesmus, and depends upon the amount of actual bladder involvement, particularly about the outlet or so-called neck of the bladder.

Referred Pain.—This type of pain already referred to, which occurs in the well kidney is the result of the stretching of the capsule due to hypertrophy. This generally occurs in rapidly destructive cases and those with early ureteric obstruction. On the whole, pain is not a reliable symptom and again the diagnosis should not be based upon it without confirmation by the cystoscope.

Summary.—To sum up the foregoing, it will be seen that the most frequent presenting symptoms of renal tuberculosis are those of a cystitis. It was formerly supposed that tuberculosis was primary in the bladder; we now know, however, that the bladder lesion is always secondary and in the majority of cases is infected from the kidney. It may be secondary to a tuberculous process in the genitals in the male or the Fallopian tube in the female. However, given a causeless progressive cystitis of insidious onset in a young person, which does not yield to ordinary treatment, the presence of a renal tuberculosis is to be suspected. If there is history or evidence of a tuberculous focus, past or present, the likelihood is greatly increased. The suspicion of a tuberculous process being aroused, the diagnosis is to be made from a careful study of the urine.

Urine.—The typical appearance of the urine in renal tuberculosis is pale, cloudy or opalescent from intermixed pus which settles on standing, leaving a clear urine above. In the early stages the twenty-four-hour amount is increased, there being an actual polyuria. This early polyuria is characteristic of the disease and should excite suspicion.

The specimen for examination should always be a catheter specimen drawn into a sterile container. The urine in renal tuberculosis is pale, acid, and contains albumin. This may come from the diseased organ or from the healthy one as the result of a secondary toxic nephritis, and may at times be detected at a very early stage of the disease. Albumin alone, without the signs of inflammation, is found at times in the presence of tuberculous lesions in other parts of the body and is not a sign of renal tuberculosis. The urine at the time patients present themselves is practically always hazy or cloudy, depending upon the amount of pus present. The sediment will contain pus and generally microscopic blood; rarely tube casts are found. One of the striking things in the examination of the sediment is the absence of bacteria ordinarily found in purulent urine. Should the urine prove sterile to culture, the probability of tuberculosis is very strong. Further evidence of the power of tuberculous urine to inhibit the growth of

bacteria is presented by the fact that if allowed to stand, the urine will remain clear for some time after the sediment has settled; whereas bacteria multiply rapidly in the ordinary pus infections and the urine soon becomes cloudy. Mixed infection with the colon bacillus and various cocci occurs in a certain number of cases and may be the result of previous instrumental trauma. It is surprising, however, to see how persistently sterile tuberculous urine remains even after repeated cystoscopic examinations.

While a sterile pyuria is more than suggestive of tuberculosis, the diagnosis can only be made by the demonstration of the tubercle bacillus in the urine, together with the products of inflammation. The only other sterile pyuria is that occasionally met with in renal calculus. As has just been stated, while tuberculous urine is generally sterile, in some cases a mixed infection with colon or some of the cocci may occur on a tuberculous base. This mixed infection, if severe, may be misleading and tend to obscure the more important lesion.

Methods of Demonstrating the Tubercle Bacillus in Urine.—The finding of tubercle bacilli alone without pus, is insufficient to make a diagnosis of urinary tuberculosis, as they are excreted in the urine of patients having pulmonary tuberculosis without any demonstrable lesions of the kidney. Such cases are reported by Brown, Bernstein, Cunningham and others. In one of the cases at the Massachusetts General Hospital in which the guinea-pig test was positive, autopsy showed tuberculosis of the lung and a chronic glomerulonephritis but no tuberculosis of the kidney. Clinically there had been a hematuria probably due to the nephritis. These tuberculous bacillurias are probably uncommon and are readily differentiated by the finding of signs of inflammation of the urinary tract, as pus and blood in the sediment. That they do occur should be borne in mind, however, and gives emphasis to the statement that positive results in guinea-pig inoculation from the urine should always be verified by an examination of the sediment.

The tubercle bacillus occurs as an acid-fast, red-staining organism and is to be differentiated principally from the smegma bacillus. Other red-staining organisms may occur in the urine but with great rarity. According to Brown, the lepra bacillus, the milk and butter bacilli and the timothy-hay bacillus may be excreted by the urine.

The smegma bacillus is met with frequently about the genitals and in the anterior urethra, and is not to be differentiated from the tubercle bacillus by staining methods, so that if the diagnosis is to be made by this procedure, the smegma bacillus must be eliminated by careful methods of procuring the urine for examination. The external genitals are to be thoroughly washed with soap and water and bichloride solution, and the anterior urethra copiously irrigated with salt solution or boric acid. Any acid-fast, red-staining bacilli found in a catheter specimen after these precautions may be regarded as the tubercle bacillus in the male, and somewhat less constantly in the female. The

urine so obtained is to be examined as follows: A high-power centrifuge is essential and all tubes and pipettes are to be sterilized by boiling. Pus and epithelial detritus sedimentize much more rapidly than do the tubercle bacilli; by remembering this fact it is possible to obtain a high concentration of tubercle bacilli with a minimum admixture of cellular elements.

If the urine is cloudy and evidently contains a good deal of pus, centrifuge at low speed for a short time, two or three minutes; this will throw down the majority of the heavy sediment, leaving a slightly cloudy urine. The supernatant urine is poured into another tube and centrifuged at high speed until the urine is *clear*. The sediment so obtained will be slight in amount but contains a large number of bacilli. If the urine is fairly clear it should be centrifuged for a sufficient time to *clear it completely*. In either case, should the amount of sediment be slight, the urine can be repeatedly poured off and the tube refilled and recentrifuged. The sediment is stained by the Ziehl-Neelson method as follows: Pour off the fluid and by means of a wire loop, spread on cover-glasses as much sediment as can be picked up.

1. Dry over flame.
2. Fix by passing three times through Bunsen flame.
3. Stain with carbol-fuschin two minutes, steaming over flame.
4. Wash in water.
5. Decolorize for thirty seconds with 30 per cent. nitric acid, followed by 95 per cent. alcohol.
6. Wash in water.
7. Counter-stain one-half to one minute with aqueous solution of methylene blue.
8. Dehydrate with absolute alcohol.
9. Clear with xylol and mount.

A competent bacteriologist will seldom fail to find tubercle bacilli if present. This method when positive, has the advantage of taking the least amount of the patient's time, but cannot be considered as accurate when negative. In the latter case guinea-pig inoculation must be employed, in fact, many people contend that even when acid-fast bacilli are found to be present, their character should be confirmed by a control guinea-pig inoculation.

At the Massachusetts General Hospital we have been strong believers in the accuracy of the pig test, and until recently have relied upon it entirely. The technic is as follows: From 20 to 40 minims of urine, obtained as previously described, is injected under the skin of the pig's abdomen. The animal is killed at the end of five weeks and an immediate autopsy is performed. Smears from the diseased organs and lymph nodes are made and stained, and the tubercle bacillus demonstrated by the microscope. The animals are selected for their health and vigor, are kept in a specially constructed room, under the best hygienic conditions and protected in every way from accidental tuberculous infection. That accidental infection of the pig may occur at times and

be suspected, is shown by the following report from the Massachusetts General Hospital Laboratory. "Autopsy shows tuberculosis of the maxillary and mediastinal lymph nodes and spleen. No tuberculosis of the axillary or inguinal lymph nodes. Inasmuch as the animal was inoculated subcutaneously in the abdominal wall, this tuberculosis in the animal must be regarded as infection by the mouth and not as the result of inoculation." A subsequent negative inoculation proved the accuracy of this observation.

The objection to this method is the length of time one is obliged to wait for a diagnosis. Its value, however, cannot be doubted, and is well shown by a series of 252 consecutive guinea-pig inoculations done at the Massachusetts General Hospital, and analyzed by Barney. Of these, 197 were definitely proved either positive or negative by operation, pathological report, and autopsy or clinical course. Among these there were 2 cases in which the pathological report showed tuberculosis of the kidney, and the pig test was negative. In one of these there was complete obliteration of the ureter, so that no urine came from the diseased kidney. In the other there was tuberculous abscess of the kidney but the pig failed to show tuberculosis. Leaving out the first of these 2 cases (in which the pig really gave accurate information) there is an error of only 0.5 per cent. in 197 cases.

While in active tuberculosis of the kidney, tubercle bacilli are generally constantly to be found in the urine, it cannot be denied that they may be absent at times, from the temporary shutting off of a tuberculous focus, or at least present in such small numbers as to escape detection. It is evident, therefore, that in the presence of symptoms, a single negative observation is not to be taken as final, any more than a single examination of the sputum would be so considered in pulmonary lesions.

In long-standing cases with total destruction of the kidney and obstruction of the ureter, the cases of so-called autonephrectomy, as cited above, tubercle bacilli are frequently absent and give color to the cases reported as cured by hygienic treatment.

Cultural Methods.—Brown and Petroeff describe a method of differentiation between the smegma bacilli and tubercle bacilli based on the inability to cultivate the former. Brown states that "Petroeff's new egg-meat-juice-gentian-violet medium will enable us to grow tubercle bacilli readily. If at the end of ten days or two weeks no growth takes place in a tube which has been inoculated with a sediment containing acid-fast bacilli, we are almost justified in concluding that they are not tubercle bacilli." An accurate cultural method would be of great value and save much time in making a diagnosis.

Cystoscopy and Ureter Catheterization.—If a tuberculosis of the urinary tract is demonstrated or suspected, its localization in the upper tract can be verified only by the examination of the urine obtained directly from one or both kidneys by ureter catheterization. The employment of any of the various forms of segregators or separators to obtain the

unmixed urine, is to be absolutely condemned. Distortions of the bladder, with the resulting displacement of the ureters, are so common that these instruments cannot fail to give inaccurate information.

General Consideration.—As has just been stated, the only way in which a diagnosis of renal tuberculosis can be verified is by the examination of the unblended urine from one or both kidneys by the employment of ureter catheterization. In many cases, from a careful study of the history and clinical symptoms, the experienced surgeon will suspect the presence of a renal tuberculosis, and resort immediately to this method of examination without wasting what may be valuable time for the patient, by a study of the bladder urine.

These tuberculous patients resent instrumentation to a very marked degree and every effort should be directed to gaining as much information as is possible from a single examination. This examination should always be made by an expert cystoscopist. Ill-advised, unskilful or prolonged instrumentation can only result in embarrassment to the operator and great discomfort to the patient. In the latter case, not infrequently, to such an extent that he will absolutely refuse any further examination. The following precautions should be observed, and their neglect may make the difference between success and failure. If vesical irritability is present, even in a moderate degree, it is wise to give the patient a preliminary course of treatment by the administration of sandalwood oil. This drug should be given in 10-minim doses three or four times a day for from one to three weeks, and will be found to have a remarkable power in quieting down the vesical symptoms. It may be supplemented with the tincture of hyoscyamus. It must be remembered that hexamethylenetetramin and the various trade compounds containing it are very irritating in tuberculous conditions of the urinary tract and should never be given in such. In fact, some regard this irritating property of the drug in tuberculosis as of diagnostic value.

Anesthesia.—Except in extreme cases, cystoscopy should be attempted at first under local anesthesia. We have abandoned the use of cocain for this on account of its toxicity, and have substituted a 5 per cent. solution of alypin made up with catheter lubricant, and have found it satisfactory where local anesthesia can be employed. In the male, 2 drams are injected into the deep urethra through a small soft-rubber catheter; in the female the urethra may be injected through a catheter or with a small glass syringe. No instrumentation should be attempted for at least fifteen minutes. General anesthesia with ether for cystoscopy is inadvisable for several reasons. For one, there is the real danger of starting up a quiescent pulmonary process which exists in many of these cases. Even gas-oxygen is not entirely safe in this respect. Another, the function of the kidneys is much diminished under a general anesthetic. Still another, the bladder reflex is not abolished and the distending fluid may be expelled as readily as under a local anesthetic.

Spinal anesthesia is by far the best method to employ when there is a very irritable bladder or one of small capacity. As the vesical reflex is abolished, a sufficient quantity of fluid to make the examination may be introduced into the bladder and retained, which would be impossible under any other method. These patients being mostly young, spinal anesthesia is well tolerated and the dangers of a general anesthetic are avoided. One c.c. of 5 per cent. novocain solution is injected low between the third and fourth lumbar vertebræ if possible, which gives sufficient anesthesia. We have employed it a number of times with no untoward results.

The operator should have ample assistance and be sure that all appliances are at hand and in working order. Preliminary cleansing irrigation of the bladder should not be undertaken until the local anesthetic has had a chance to work, even then, small quantities of fluid should be used at a time, as the tuberculous bladder is very sensitive to overdistention and vesical spasm is easily induced, which will make the examination difficult or even impossible.

Cystoscopy in vesical tuberculosis is not without its dangers and it is to be remembered that these contracted and ulcerated bladders may be ruptured by overdistention, or even perforated by the cystoscope. We have personally seen a skilled operator pass a cystoscope through a much-contracted and ulcerated bladder directly into the peritoneal cavity without using undue force or causing pain to the patient. The abdomen was immediately opened and the puncture sutured, with no untoward results. There is reason to suppose that a ureter catheter may be forced through a much-diseased tuberculous ureter, although we have never seen this occur. In some cases, even in the hands of the most expert, and after all preliminary precautions have been taken, the examination will be unsuccessful for any of the following reasons: A very irritable bladder, excessive bleeding, the presence of ulceration or edema sufficient to obscure the ureter, or when there is great deformity of the bladder from an old tuberculous cystitis, or from marked retraction of the ureter.

Inspection Cystoscopy.—The appearances of the bladder mucous membrane may or may not be characteristic of tuberculosis. In some cases there may be little or no involvement of the bladder, in others the picture is that of a general acute cystitis, the mucous membrane being reddened, granular, and light-absorbing, with here and there flakes of adherent mucopus. In the majority of cases the inflammatory process is confined to the area about one or the other of the ureteral orifices but the picture cannot be said to be typical of tuberculosis unless we see the minute miliary tubercles which appear as small gray nodules, surrounded by an inflammatory zone. These tubercles have a tendency to break down, forming small, shallow, irregular ulcers. Such a picture appearing about one of the ureters is a definite indication that the kidney on that side is diseased. Edema of varying degrees is also frequently to be observed about the trigone or either

of the ureters. No less important are the changes in appearance and position of the ureteral orifice itself. Besides the reddening, there is to be seen at first a slight thickening and stiffening of the orifice from the infiltration about it. This is evidenced by its sluggish action during an efflux and its failure to close entirely. The ureter mouth itself may be the site of ulceration, and as the process extends, becomes transformed into an irregular gaping hole surrounded by edema. By far the most typical lesion of the advanced tuberculous ureter is retraction; this is not necessarily accompanied by ulceration. Here, instead of the orifice being on a projecting mound, it is drawn inward by the thickening and shortening of the diseased ureter and appears as a deep funnel-shaped cavity. This retraction frequently takes place to such an extent that the diseased ureter is high on the lateral wall, pulling the trigone around until the normal ureter appears in the median line. This type of ureter is often associated with what is known as closed renal tuberculosis (tuberculosis occlusia). There is complete blocking of the ureter, with ultimate destruction of the kidney (Figs. 202 and 203).

Ureter Catheterization.—While inspection cystoscopy is frequently of use in helping to localize the process in one or the other kidney, no amount of observation will give us the functional worth of any given kidney, and ureter catheterization should always be resorted to. In the presence of an obviously diseased ureter it is not only unnecessary, but unwise to attempt to catheterize any but the supposedly sound side. These markedly diseased ureters are frequently more or less obstructed, so much so that the passing of a ureter catheter a sufficient distance to obtain a reliable specimen may be difficult or impossible. On the other hand, they may be so dilated that the urine will run alongside of the catheter instead of through it. Constitutional symptoms not infrequently follow instrumentation of the diseased kidney as is shown by fever and malaise lasting for several days. In fact, at times patients have far more reaction after cystoscopy and ureter catheterization than after nephrectomy. If the changes about the ureter are slight, or both appear to be involved to the same extent, meatoscopy is not to be depended upon but both sides are to be catheterized. If there is only a moderate cystitis, this operation presents no particular difficulties in the hands of the experienced. However, if there is considerable edema and ulceration, the recognition of the ureters may be extremely difficult and in some cases impossible.

Also, there is another class of cases in which the cystoscopic picture may be very puzzling; these are the old long-standing ones, where a previous vesical tuberculosis has become healed following the total destruction of the kidney, with a good deal of contraction and deformity of the bladder due to scar tissue.

Chromatocystoscopy, so-called, may be of use in these cases in recognizing the ureters. A solution of indigo-carmine is injected subcutaneously, which being excreted by the kidneys colors the efflux a

deep blue. By the location of this colored jet an otherwise unrecognizable ureter may be found; as a rule this method is of value only when the patient is under general or spinal anesthesia, as during the additional time required for the appearance of the color (ten to fifteen minutes) the bladder may become intolerant.

A sufficient quantity of urine (10 to 20 c.c.) for chemical and microscopic examinations, culture, and guinea-pig inoculation is to be collected from one or both kidneys as the case may be. The catheter should be passed well up into the kidney pelvis, or the pelvic portion of the ureter. The flow should be the typical interrupted succession of a few drops at a time, except in the presence of a hydronephrosis. Sometimes a very active kidney will give an almost continuous flow, as will a hydronephrosis. This condition may be simulated by regurgitation of fluid up a dilated ureter and siphonage through the catheter, which should be borne in mind, particularly if the passage of the catheter is obstructed. The condition can be readily demonstrated by making sure that all the distending fluid is removed from the bladder and injecting some boric acid solution colored with methylene blue; if regurgitation is taking place the colored solution will appear through the ureter.

Examination of the Separate Urines.—The absolute diagnosis is now to be made by a careful chemical and physical examination of the separate urines. Given a typical case of unilateral renal tuberculosis, the urine from the infected side as compared with the normal will be cloudy, paler in color, faintly acid, the specific gravity will be lower, as will also be the urea output. Albumin will be present. The sediment will contain pus, possibly blood, and tubercle bacilli can be demonstrated by the method already outlined (p. 519). In early cases there may be a polyuria of the infected kidney, so although it may secrete a greater quantity of urine, the functional ability is always diminished.

The sediment of the sound or supposedly sound side should always be carefully examined for pus. If pus is present the kidney is to be suspected and guinea-pigs inoculated. If there is no pus it may be assumed that there is no renal tuberculosis. A trace of albumin may be found and is due to the irritation or toxic nephritis produced by the lesions in its fellow. A little microscopic blood is generally present and may be safely attributed to the trauma of catheterization.

Phenolsulphonephthalein Test.—This test we believe to be the best, as well as the simplest of application, of all the functional tests, and it should be carried out in all cases when possible, in addition to the physical and chemical examinations of the urine. The divided function as well as the total function may be estimated.

The Divided Function.—After a sufficient quantity of urine has been collected from each kidney for routine examination, 1 c.c. of a solution containing 6 mg. of phenolsulphonephthalein is injected intravenously or intramuscularly. (This drug is conveniently put up in ampoules

containing the necessary amount.) The urine is then allowed to drop into test-tubes containing a few c.c. of 25 per cent. solution of sodium hydrate. The beginning of the elimination of the drug is shown by the appearance of deep magenta color. The urine is to be collected for a period of fifteen minutes from the time of appearance and the percentage of the drug eliminated estimated by means of a color scale. A small catheter should be placed in the bladder to estimate any leakage from a dilated ureter which would, of course, vitiate the findings. If only one ureter is catheterized, the urine from the other kidney may be collected by a catheter in the bladder. The time of appearance in a healthy kidney is from five to seven minutes. If the drug is given intravenously its time of appearance is shorter. In the tuberculous kidney the time of appearance is generally delayed and the percentage excreted is always diminished compared with the well kidney. The divided function is of value in comparing the relative activity of both kidneys. It may also be of value in showing whether or not the healthy kidney is of the so-called infantile type. Here the time of appearance is normal but the percentage estimated is diminished and the small kidney may be unable to sustain life in the absence of its diseased fellow.

The Total Function.—The total function is obtained by passing a catheter into the bladder and noting the time of appearance of the color. All the urine is collected, either by being voided or by a catheter, for a period of one hour from the time of appearance and the percentage estimated. Normal kidneys should eliminate from 40 to 60 per cent. in this time. In bilateral renal lesions the total function is always diminished, sometimes considerably so, and the time of appearance delayed. In unilateral disease the function may vary from approximately normal to moderately depressed, but here the total function is of little value compared to the divided. We believe that the function of the healthy kidney is temporarily depressed in the presence of a tuberculous organ on the other side.

Radiography in Diagnosis.—By the x-ray, the substance of the tuberculous kidney appears more dense than does the normal organ and the lobulated outline may be well shown. Calcified areas in the kidney and calcified glands in the region of the pelvis may simulate calculi, but can generally be differentiated by their irregular outline and mottled appearance.

In the presence of an obstructed ureter, the x-ray may confirm the suspicion that the kidney has been entirely destroyed by caseation (Figs. 207 and 208).

Diagnosis by Operation.—There are certain conditions where the obstacles to cystoscopy are insurmountable, such as (1) renal tuberculosis in small children; to be sure this is rare, but we recently had a case at the Massachusetts General Hospital in a child of eight; (2) in the presence of a tuberculous stricture, or (3) a much-contracted

or ulcerated bladder, or (4) a hip-joint ankylosed in such a position as to prevent instrumentation. In the presence of any of these, diagnosis must be made by operation and various procedures such as opening the bladder and attempting ureter catheterization, the temporary occlusion of one ureter to obtain the urine from the other, or the exploration of the supposedly well kidney, have been suggested and practised.

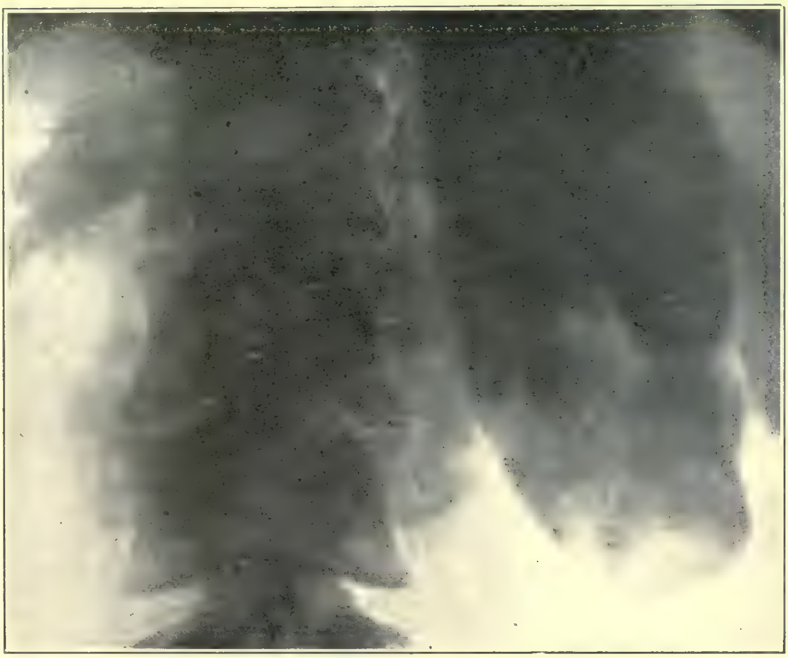

Fig. 207.—Radiograph showing complete destruction of kidney by caseation with calcification. (From the X-ray Dept. of the Massachusetts General Hospital.)

A far more accurate and more simple method, we believe, is the extraperitoneal exposure and palpation of the ureter at the pelvic brim. The lower end as well as the upper end of the ureter is involved in renal tuberculosis and the thickened pipestem-like tuberculous ureter is a sure indication of the diseased kidney above. The operation can be done easily and quickly, and exposes the patient to but little danger, which cannot be said of the other procedures.

On the basis that palpation of the upper end of the ureter is just as accurate, Keyes advocates a loin incision, using the argument that if the ureter is found diseased, the kidney may be explored and nephrectomy done through the same incision. It seems, however, that it would not infrequently be necessary to carry this procedure out on each side,

which is considerably more of an operation than the exploration of the ureter at the pelvic brim.

Fig. 208.—Radiograph showing tuberculosis of pelvic portion of the ureter. (From the X-ray Dept. of the Massachusetts General Hospital.)

COURSE AND PROGNOSIS OF TUBERCULOSIS OF KIDNEY AND URETER.

Renal tuberculosis is a disease of insidious onset which runs a slow, progressive, downward course and unless modified by surgical treatment ends in death from renal insufficiency or disseminated tuberculosis anywhere from five to ten years after the appearance of symptoms. In some cases in the younger patients, and those in which a mixed septic infection has occurred, the progress is much more rapid. Characteristic fluctuations occur during the course of the disease. There may be periods of marked improvement in the symptoms with the disappearance of pus and tubercle bacilli from the urine for intervals of months or years, due to the fact that the tuberculous focus in the

kidney becomes shut off. Such a focus, however, is to be regarded only as latent and sooner or later symptoms are sure to make their reappearance.

As has been stated, spontaneous cure of renal tuberculosis does not occur. At times the ureter becomes obliterated and the kidney completely destroyed. Even these old dead kidneys have been found to contain tubercle bacilli and are to be regarded as a source of danger.

In regard to the prognosis in operated cases, as has been stated, the immediate mortality from the operation should not exceed 3 per cent. The later mortality is estimated between 10 and 20 per cent.; the great majority of these deaths occurring within the first two years. The prognosis, therefore, in unilateral cases after two years, is excellent, about 3 per cent. of the cases dying of tuberculosis beyond that time. Of course the presence and extent of tuberculous lesions outside of the urinary tract will have a marked influence on the prognosis in any given case. This has already been discussed.

In our experience, certain young individuals with early lesions which show considerable cortical tuberculosis and perinephritis do less well after nephrectomy than those of a more advanced age, but in whom the disease is often more extensive. The reason appears to be the establishment to a certain extent of an acquired immunity. The practicability of artificial immunization of these individuals demands consideration. Whether it will ever be advisable to wait in certain cases for immunization to take place before nephrectomy is done, cannot be answered without much more data; at present there is but one treatment: immediate operation as soon as the diagnosis is made. The factor of resistance cannot be measured and there are early cases which do well after nephrectomy.

We ordinarily classify as cured such patients as are in good condition, who have gained in weight, who present no evidence of the disease, or in whom no new foci have developed; who also show improvement in the bladder symptoms, and no active lesions in the urinary tract. Sixty per cent. of our cases conformed to these requirements.

The term unimproved we apply to such patients who have not maintained their gain in weight; whose physical condition is below normal; who still have active lesions of the genito-urinary tract, or in whom the disease has progressed and new lesions are active, and in whom nephrectomy has not afforded the expected retardation of the disease. 12.8 per cent. of our cases are so classed.

TREATMENT OF TUBERCULOSIS OF THE KIDNEY AND URETER.

The treatment of renal tuberculosis is operative and by general measures such as hygiene, climate, diet and tuberculin. It may be said here that there is no convincing report in literature of a cure of

renal tuberculosis by hygienic and general measures. There are cases where tubercle bacilli have disappeared from the urine and symptoms have been relieved for a long period, but it has always been at the expense of the complete destruction of the kidney by caseation (Figs. 202 and 203). To obtain the best results, operative treatment is always to be followed up and supplemented by all general measures.

The line of treatment to be followed is influenced mainly by two factors: (1) The condition of the other kidney, (2) the nature and extent of tuberculous processes in other organs.

Operative Treatment.—As has been shown previously, the presence and condition of the supposedly well kidney must be known. If the disease is unilateral the only treatment is operation and this means total nephrectomy which should be performed as soon as the diagnosis is made.

Indications and Contra-indications for Operation.—As has just been stated, in unilateral cases nephrectomy is the best therapeutic measure which we possess and the only one which holds out the prospect of a cure, and as such should be urged to its utmost.

Toxic Nephritis in the Other Kidney.—The presence of a toxic nephritis, already referred to as evidenced by albumin and casts, is not a contra-indication to nephrectomy unless severe, as shown by a low phenolsulphonephthalein output. This nephritis is due to the irritation produced by the elimination of toxins and tends to recover after the removal of its diseased fellow.

Other Tuberculous Lesions in the Body.—Extensive lesions of the lungs, the spine, the genitals (to a less extent), the peritoneum, and multiple joint lesions, when accompanying renal tuberculosis are definite contra-indications to nephrectomy. To operate in the presence of any of these is to invite a rapidly fatal general miliary infection. A moderate pulmonary process should receive sanatorium treatment in the hope that it may be rendered sufficiently quiescent to permit of operation later. During this time, of course, the other kidney may become infected and the case should be reëxamined before being subjected to operation. As a general rule tuberculous foci in other parts of the body except when so extensive as to preclude operation, show an improvement and a tendency to recover following nephrectomy. This is particularly true of vesical and ureteral tuberculosis and such lesions, even if extensive, are no contra-indication to nephrectomy.

Operation in Bilateral Cases.—Bilateral disease is almost always a definite contra-indication to nephrectomy. However, the removal of the markedly worse of the two kidneys has been advocated and practised. While nephrectomy in bilateral disease has undoubtedly been done unknowingly when the process in the other kidney was very early or was still a closed lesion which had not manifested itself, it should not be done deliberately, without serious consideration, as the remaining kidney may be unable to sustain life in the absence of its fellow. Given, however, a totally destroyed organ on one side and one only slightly

diseased, as shown by a small amount of pus and a good renal function on the other, it is arguable that removal of the non-functionating organ will have a beneficial effect on the remaining kidney by relieving it of the irritation of the excretion of toxins. The general health will probably be temporarily benefited by the removal of such a focus, and vesical symptoms, if present, may be ameliorated. It is to be remembered, however, that it will not check the process in the other kidney and will probably not prolong life. It is to be regarded as a palliative measure.

The operative procedures which have been employed are, partial nephrectomy, nephrotomy, and nephrectomy.

Partial Nephrectomy.—Resection of the kidney has been recommended and practised in selected cases. A glance at the pathology, however, will show how impossible it is from inspection to estimate the extent to which the kidney is infected. For this reason it is a poor operation and should never be employed.

Nephrotomy.—This operation has a limited use in renal tuberculosis and is employed for drainage only when the patient's condition is such that primary nephrectomy cannot be performed. It may be stated here that primary nephrectomy is to be done whenever possible, as the difficulties of a secondary nephrectomy add very distinctly to the danger and mortality of the operation. Nephrotomy is occasionally performed as a palliative measure for the relief of distressing vesical symptoms in bilateral disease.

Nephrectomy.—As has been already emphasized, this is the only surgical procedure which holds out the prospect of a cure. There are some features in the technic which are of special interest when this operation is performed for tuberculosis. In the early cases the operation presents no particular difficulties for the trained surgeon. In the more advanced ones, when the kidney has become enlarged from pyonephrosis and adherent to the important structures from repeated attacks of perinephritis, the operation may be one of great difficulty and danger. We employ the lumbar retroperitoneal approach.

Anesthesia.—We consider this of great importance and because of the fact that so many of these cases have had a previous, or have a quiescent pulmonary process we employ gas-oxygen as a routine anesthetic, as being much less liable to produce irritation in the lung than any other. The only disadvantage is that it requires an expert for its administration.

Position.—The patient is placed upon the well side, with the lower leg flexed both at the hip and knee and the upper leg extended. A sand-bag or pad is placed under the loins in such a way as to increase as much as possible the space between the border of the ribs and the iliac crest (Figs. 209 and 210). At times, because of previous lesions of the spine causing a kyphosis, or from disease of the hip-joint, this space is materially diminished, which adds very greatly to the difficulties of the operation.

Incision and Operation.—We employ the ordinary oblique incision, starting just below the middle of the 12th rib and parallel to it and carrying it forward as far as is necessary an inch in front of and parallel to the crest of the ilium. If additional room is needed at the upper

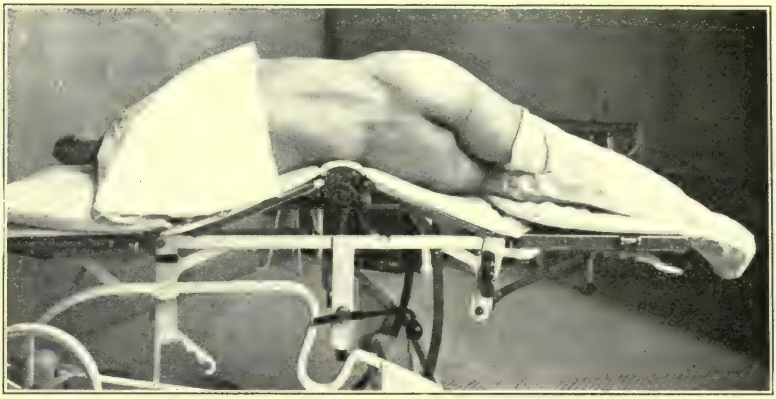

Fig. 209.—Patient in lateral position for nephrectomy showing method of increasing distance between costal margin and crest of ilium by means of specially constructed operating table. (Photo by X-ray Dept. of the Massachusetts General Hospital.)

end of the incision, the 12th rib is exposed and the fibers of the lumbocostal ligament divided, which allows the rib to be dislocated upward and greatly increases the space. Care must be taken not to wound the

Fig. 210.—Same, showing the use of sand-bag under the loin to increase space between the costal margin and crest of ilium. (Photo by X-ray Dept. of the Massachusetts General Hospital.)

pleura, which comes down to the upper border of the 12th rib. This incision is varied somewhat according to the amount of space between the ribs and crest of the ilium, the narrower the space, the more perpendicular the incision. Sometimes when the kidney is much enlarged

from pyonephrosis, a transverse incision is used, beginning at the border of the rectus and extending directly back over the most prominent part of the mass.

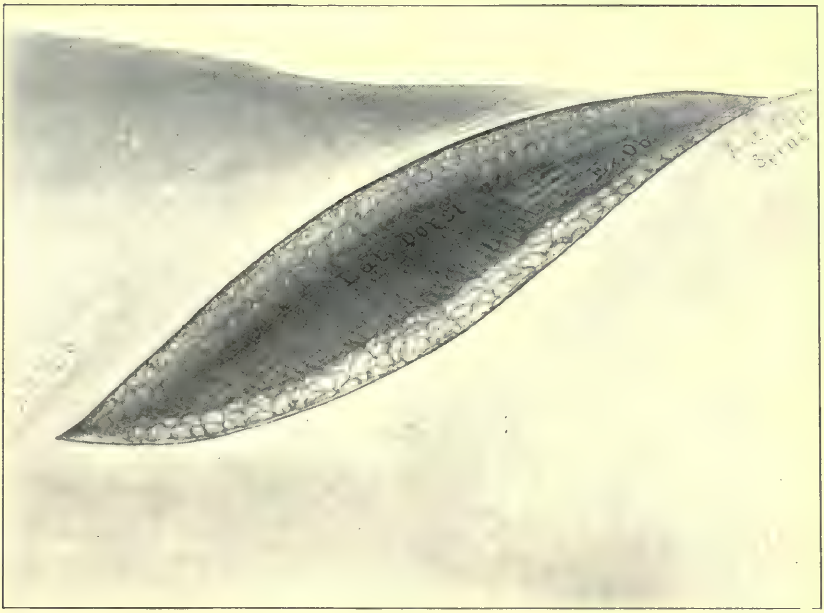

FIG. 211

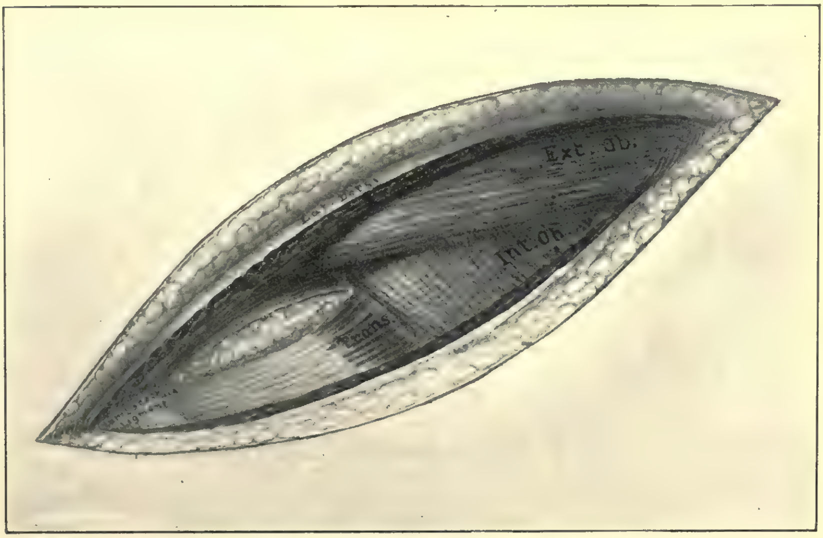

FIG. 212

The incision is carried down through the muscle planes until the muscular space is reached, which is the space in the lumbar fascia at the posterior end of the incision formed by the 12th rib with the lumbocostal ligament above, the sacrospinalis posteriorly; in front, above by the external oblique and below by the internal oblique and transversalis. This space is the direct lead to the kidney. The fingers of the left hand are then introduced under the muscles, the peritoneum being pushed downward and inward, they are then divided to the extent of the skin incision (Figs. 211 to 217). In this dissection care must be taken to avoid wounding the 12th dorsal and the ilio-inguinal nerves,

FIG. 213

which parallel the incision and cross at its lower part. On dividing the lumbar fascia, the fat capsule comes into view. This is to be opened with scissors and the incision enlarged by tearing with the fingers. The kidney is now to be freed from the perirenal fat by means of the fingers, beginning at the upper pole. The difficulty in this procedure depends entirely upon the amount of perinephritis present. Any particularly firm bands of adhesions are to be divided between ligatures. After freeing the kidney, the ureter is to be sought for and freed as far down as possible. There is always some abnormality of the ureter present. The typical tuberculous ureter is thickened, stiff,

and pipestem-like. The ureter is to be divided between two clamps and the ends ligated and cauterized. Division of the ureter will greatly

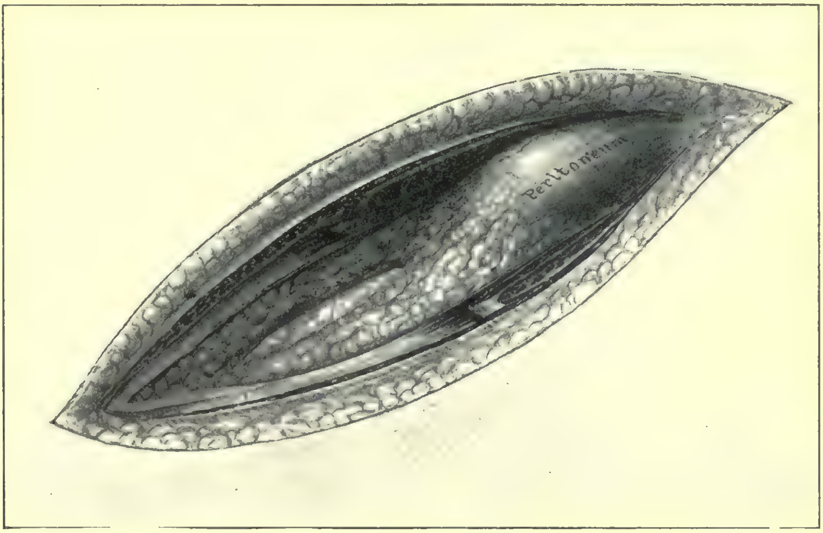

FIG. 214

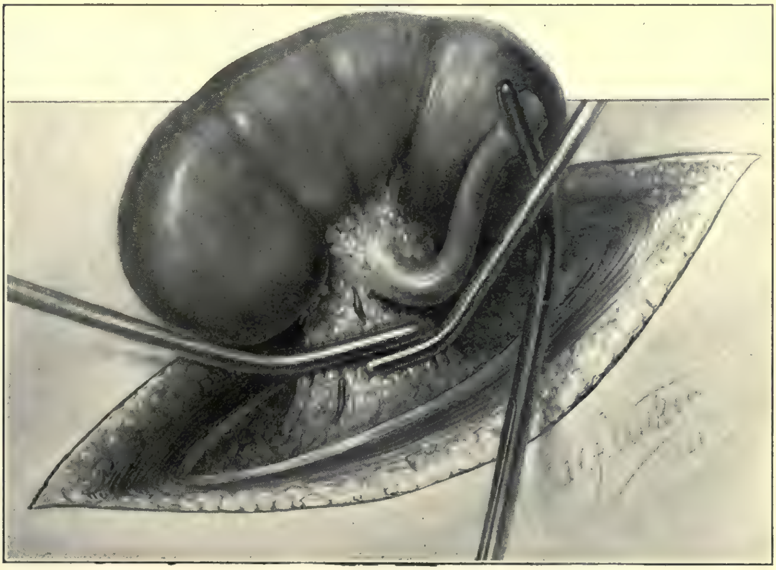

FIG. 215

assist in the mobilization of the kidney which in most cases can be delivered on the loin. The pedicle should be developed as much as

possible and clamped from behind forward, leaving as much space as is available between the clamp and the kidney. This clamp should be reinforced by another one put on from in front, crossing it. Great

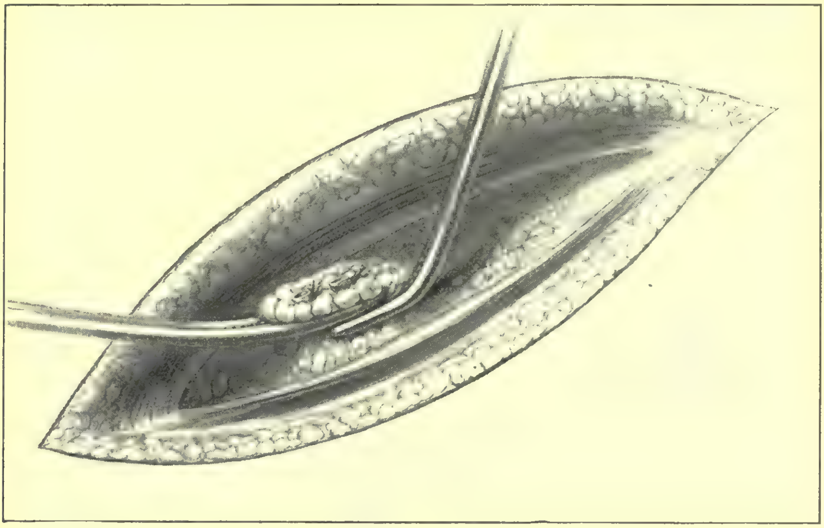

FIG. 216

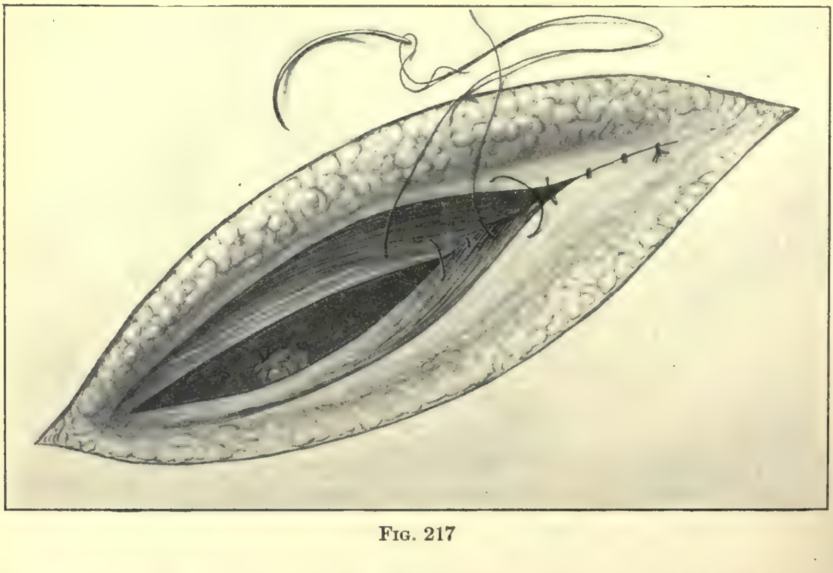

FIG. 217

care must be taken to ensure that the renal pelvis is entirely freed from the pedicle and not included in the clamp. The pedicle is now divided and the kidney removed without opening the renal pelvis. The vessels

are to be searched for in the pedicle and ligated separately *in front of* the clamp. The pedicle is then either transfixed and ligated with a double ligature or else a mass ligature is put on behind the clamp and tightened as the clamp is removed. This latter procedure is the one which we generally employ. Where there is a great deal of thickening of the pedicle, or it is short, or the condition of the patient will not warrant spending any extra time, the clamps may be left in place. The handles should be tied together, and the clamps removed in from five days to a week. The wound is closed in layers, and if there has been no leakage of pus from the kidney, or there is no marked perinephritis, it is closed without drainage after the injection of 10 ounces of salt solution into the cavity. If there has been considerable oozing, a small rubber tissue drain may be put to the bottom of the cavity. In the presence of a pyonephrosis it may be necessary to reduce the size of the tumor in order to deliver it or get at the pedicle. This should be done by tapping or aspirating, closing the holes so made by means of a clamp to prevent spilling tuberculous material into the wound.

Accidents during Nephrectomy.—*Injury to the Pleura, Peritoneum and Bowel.*—Wounds of the peritoneum and less commonly of the pleura occur during the course of this operation. If they are recognized and immediately closed by suture, no harm will result. In the advanced case, where the kidney is considerably enlarged from pyonephrosis and adherent from perinephritis, the bowel may be torn in the attempt to separate the firm, dense adhesions, in which case it should be immediately sutured.

Hemorrhage.—This may occur during the operation from various sources. In separating the kidney from perirenal adhesions, an aberrant vessel may be torn and if unrecognized may give rise to extensive bleeding. The avoidance of rough manipulation, and proper ligation of any suspiciously dense band of adhesions before division, will guard against this occurrence. Severe and dangerous bleeding may occur from the renal pedicle from the slipping of the clamp or of the ligature after the clamp has been removed, due in either case to the division of the pedicle too close to the clamp. Again, the renal vein may be injured behind the clamp in an attempt to transfix the pedicle. Rapidly fatal hemorrhage may occur from any of these. The pedicle, or bleeding-point, should be immediately seized with the fingers or a clamp. If the operator is fortunate enough to control the bleeding, another ligature should be applied to the vessel or to the entire pedicle; if there is any difficulty in placing the ligature, the clamp had better be left on and removed at the end of a week.

These accidents are best guarded against by a careful dissection and development of the pedicle and placing the clamp as far from the kidney as possible. The vessels should be picked up separately and ligated in front of the clamp before the mass ligature is put on.

Injuries to the vena cava have also occurred during the attempt

to deliver an adherent kidney. This is a very serious accident and an attempt should be made to control the hemorrhage by suturing the rent in the vein. If the tear is a small, lateral one it may be picked up with forceps and a ligature placed about it.

Shock.—This follows nephrectomy as a rule in direct proportion to the length of time consumed, the difficulties of the operation and the skill of the operator. Prolonged manipulation and traction on the pedicle, and forcible retraction, are potent factors in the production of shock in kidney operations. It is to be treated in the usual way by the employment of heat, stimulation, and the administration of salt solution, either subcutaneously or by rectum.

Anuria.—With careful pre-operative study of the condition of each kidney, this should not occur very frequently. Reflex anuria does occur at times, however, and is treated by administration of salt solution, heat, etc.

Treatment of the Ureter.—Our practice is to free and remove as much as we can through the oblique incision, that is, removing the ureter about to the pelvic brim. To do a complete nephro-ureterectomy means extending the incision considerably and prolonging the operation. We have also at times removed the lower portion of the ureter through a muscle-splitting incision just above Poupart's ligament, through which the ureter may be pulled down extraperitoneally from above and considerably more of it removed. However, we have not found that the cases in which this was carried out, did any better than the others. It is a well-known fact that the upper and lower ends of the ureter are the portions most frequently involved in tuberculosis, and in order to carry the operation out to its logical conclusion we should be obliged to remove, not only the ureter, but a portion of the bladder as well, which is obviously not to be recommended. We know that both ureteral and vesical tuberculosis tend to heal after operation and therefore we content ourselves with the removal of as much of the ureter as we conveniently can. Undoubtedly the stump of the ureter will occasionally keep open a sinus, or act as a focus for vesical tuberculosis, but in most cases it will in time become transformed into a fibrous cord.

Wound Healing.—Of late we have adopted the course recommended by the Mayo Clinic, and after the removal of the kidney have closed the wound without drainage. After making sure that there is no rent in the peritoneum, the muscles are sutured in the usual way, a rubber tube being left to the cavity. Ten ounces of salt solution are injected, the tube withdrawn and the wound closed.

On looking these cases up, we find that in 25 per cent. we obtained primary union, in the remainder the wound reopened or abscesses formed, anywhere from three to five weeks after leaving the hospital. The majority of these, however, closed within a few weeks. In spite of the fact that the large majority of these wounds broke down, we regard the procedure as one which saves the patient much time and

discomfort, and even if not always successful, it is desirable to try for primary union in wounds which may become as troublesome as these. Sometimes the sinus may persist for a number of months, and again in other cases where extensive tuberculous infection has occurred, the wound may break down throughout its entire length and take many months to heal. In the cases where extensive breaking down has occurred, the wound after a time presents a bright red granulating surface, with no tendency to heal. Under these conditions we have performed a secondary suture with brilliantly satisfactory results.

Results of Nephrectomy.—*Gain in Weight.*—Gain in weight after nephrectomy is generally to be noticed in all patients. At times this has been so to a very marked extent, some of our patients having experienced a gain of fifteen, twenty, twenty-five and thirty pounds. Most of these have been made within a few months after operation. Parallel with the increase in weight goes an improvement in color and general condition. This gain in weight may be temporary or permanent, but the majority of the cases in our series have maintained their weight.

Persistence of Urinary Symptoms.—Most of these patients have suffered for a varying length of time, from months to years, previous to operation, from pyuria and frequent and painful micturition. The amount of pus in the urine diminishes in all cases after operation. In some cases the urine becomes perfectly clear, in others nearly so, but in the majority of patients, the urine remains cloudy for a long time. The pain and burning on micturition are generally much relieved, the frequency, however, varies between very wide limits. This depends upon two causes: (1) the amount and extent of the tuberculous cystitis; (2) the capacity of the bladder. Frequency due to the former may be expected to improve as the tuberculous cystitis heals. In the old long-standing cases, however, where there is a contracted cicatricial bladder, little improvement is to be expected. Forcible dilatation in this type of bladder may be of some help. In the treatment of tuberculous cystitis we do not as a rule employ local treatment to the bladder, although many advocate the use of irrigations with weak bichloride of mercury (1 to 25,000), or the instillation of gomenol oil, also, there are strong advocates of the Rovsing carbolic acid treatment. This treatment consists in the instillation of 50 c.c. of a 6 per cent. aqueous solution of carbolic acid at 95° F. after the bladder has been cleaned of all pus. This is done several times until the washings return clear. The pain is intense, morphin being required. Instillations are at first daily, but the interval is gradually lengthened to three or four days as the urine gets clearer. The treatment lasts one to six months. On the whole, frequency is a stubborn symptom, but usually lessens as time goes on. In cases, however, in which there is no improvement at the end of two years after operation, little further is to be expected in this direction.

Albumin in small traces may be found persistently in the urine after

nephrectomy, but the presence of small amounts of albumin and pus is not necessarily evidence of active secondary lesions. The condition is obscure, and cystoscopic examination as well as guinea-pig inoculation fails to reveal the cause. These cases are properly considered cured of tuberculosis but are not free from the effects of the disease, which have resulted in permanent damage to the genito-urinary tract.

Immediate Mortality.—This should be properly considered to be death due directly to the operation and taking place in the hospital where the patient is under observation. The immediate mortality has been greatly diminished of late years because of the accurate study of the condition of each kidney and the improvements in anesthesia and operative technic. The older series of statistics with their high mortality are of historical interest only, as showing the marked reduction that has been brought about in the death-rate. For example: Brodeur up to 1890 reports a mortality of 58 per cent.; Palet up to 1893 one of 40 per cent. and Pousson up to 1902 one of 28.4 per cent. In comparison with this the mortality of Albarran, Barth, Caspar, Cathelin, Czerny, Dollinger, von Frisch, von Illyes, Israel, König, Kronlein, Kuster, Nicolich, Pousson, Rafin, Recsey, Rovsing, Rotter, Schede, Tuffier, Wildbolz, and Zuckerkandl in the years 1902 to 1908 for 847 cases operated upon was 11.1 per cent. Wildbolz reports his immediate mortality for the years 1902–14 for 139 cases at 2.8 per cent. Asakura for the years 1905–10 had 5.7 per cent of deaths. Israel's collection of 1023 cases reported in 1911 had a mortality of 12.9 per cent. Von Frisch reported in 1911 a series of 100 nephrectomies with a 10 per cent. mortality. Braasch in 1912 reported 203 nephrectomies with a mortality in the hospital of 2.9 per cent.

Our own series of 103 gives an immediate mortality of 3.8 per cent.; even this is higher than our rate today. It would seem a fair statement that in competent hands the operative mortality should not be over 2 or 3 per cent.

Causes of Operative Mortality.—From the study of series of cases reported from various sources, pneumonia is the most frequent immediate cause of death. In our series we found that in all cases of pulmonary complications where the anesthetic was mentioned, ether had been used. The next most frequent causes are "shock," and hemorrhage at the time of operation. Other less frequent causes of death are secondary hemorrhage; reflex anuria ending in uremia; acute nephritis in the remaining kidney; cardiac failure; injury to the colon; endocarditis; acute miliary tuberculosis; thrombosis of the renal vein of the opposing side, and pyelonephritis of the remaining kidney. Death from embolism following nephrectomy seems to be a rarity, no such cases being reported in our series nor in any other that I have been able to find.

Late Mortality.—The late mortality may be defined as death occurring from tuberculosis subsequent to the temporary relief afforded by the operation. It is variously estimated as from 10 to 20 per cent.

The great majority of such deaths occur within the first two years. In our series 50 per cent. occurred within this time and the remaining 50 per cent. occurred within five years, when the disease was unilateral.

From the study of the statistics of large numbers of cases, the most common causes of death in the later mortality seem to be in the following order: general tuberculosis, pulmonary tuberculosis, tuberculous meningitis and miliary tuberculosis. Both meningitis and miliary tuberculosis are more frequently met with in genito-urinary tuberculosis than in any other forms of the disease.

General Hygienic and Tuberculin Treatment.—The general treatment is indicated in those cases in which operation is either refused or contra-indicated, as in bilateral lesions, or in patients with a unilateral lesion, presenting other extensive tuberculous foci, and as an adjunct to the operative treatment. In the operative cases it is to be remembered that in renal, as well as in other non-pulmonary forms of tuberculosis, the operation is but an incident in the course of treatment, an important part of which comes before and after operation. That is to say, it is rarely possible for the surgeon to remove all of the diseased tissue, the aim being to render the condition of the local lesion as favorable as possible for cure, which can only be obtained after months of careful supervision.

In conditions such as renal tuberculosis, which require quite extensive operation, the surgeon must recognize that his obligation to the patient does not terminate with his discharge from the hospital, and some provision for careful and intelligent treatment must be made if good results are to be obtained. For this reason we insist that all operative cases should be under constant observation and receive practically the same general and hygienic treatment as those in which operation cannot be done. What is said in regard to this treatment in one class of cases applies equally as well to the other.

At the Massachusetts General Hospital there has been organized for the treatment of surgical tuberculosis what is known as the "tuberculin clinic." In a way this is a misnomer, for while after operation tuberculin is often used, it is used in connection with other measures, as in this clinic a general supervision of the patients is maintained. In some of the genito-urinary cases it would seem as if the use of tuberculin was really an important factor. In the majority, however, while a factor, it is by no means the most important one. The tuberculin used is in bouillon filtrate supplied by E. R. Baldwin, of the Saranac Laboratory. It is administered at first once a week according to the rules of Trudeau, the initial dose being from 0.0001 to 0.0005 of a milligram. This is gradually increased to 50 or 100 milligrams, the increase of dosage being gauged by the careful investigation of the clinical signs of reaction, local, focal and constitutional. Constitutional reaction is to be avoided, and as a rule it is possible to carry patients up to a considerable dose without discomfort. Patients are asked to report once a week, when a careful physical examination is

made, particularly regarding the chest condition. A record of the weight, pulse, and temperature is kept; also the home conditions are investigated and from the first visit every effort is made to secure the patient's coöperation so that he or she will understand the reason for everything done. Patients are urged to attend once a week. In many cases this cannot be done, and some compromise has to be made, as once in two weeks and later once a month or once in two months.

It is advisable that patients with renal tuberculosis give up work for the first two or three months after operation if possible. This, however, is not always feasible, and in many cases they keep at work during the entire course of after-treatment, the general condition being so good that enforced idleness seems an unnecessary hardship.

If a patient is under weight, one quart of milk a day is added to the ordinary diet and occasionally olive oil after meals. Drugs are rarely used, except where there is painful micturition. Then, capsules of sandalwood oil or guaiacol carbonate are given. It is to be emphasized that hexamethylenamin and compounds containing it are irritating in urinary tuberculosis and should not be given. All patients are advised to sleep out of doors if possible.

Such in brief is the regime. There can be no doubt of the psychical effect of the treatment, for which the patients will return, thus enabling us to keep them under observation with greater regularity and for a much longer time than we otherwise could.

The improvement noticed in these cases may be put down to a judicial combination of surgery, hygiene, tuberculin, and a careful consideration of the individual need of each patient, rather than to any one of these alone.

As to the results obtained, most of the patients show a consistent and considerable gain in weight, in general physical well-being and in the relief of urinary symptoms. With regard to other tuberculous foci in the body, involvement of the bladder and genitals have shown considerable improvement. Regarding the bilateral cases or those unilateral cases having extensive processes elsewhere, about all we are able to say is that these cases have shown some temporary improvement but, as a rule, they have succumbed to renal failure or general tuberculosis before sufficient time has elapsed for the tuberculin and general treatment to be of any great value.

Climate.—Persons suffering from renal tuberculosis should, so far as possible, live in a warm climate which is free from sudden and great variations in temperature. This, of course, is not within the reach of many so afflicted.

Pregnancy in Renal Tuberculosis.—It may be stated broadly that pregnancy in the nephrectomized for tuberculosis should not be permitted to occur before the expiration of two years after operation for reasons already discussed under the course and prognosis of the disease. At this time the question should be considered from the following points of view. Firstly, that of the renal function; if this is below

normal, the strain of pregnancy is definitely to be avoided; and secondly, the presence of a tuberculous process in the urinary tract which is practically certain to be lighted up. Tuberculous lesions of other organs, particularly the lungs, of course have a very definite bearing upon the question, but their discussion is out of place here. Many cases are reported in literature of pregnancy following nephrectomy without harm to the remaining kidney. Kronlein reports a case in which labor occurred four times. In our own series several women have undergone multiple pregnancies successfully.

Nephrectomy for tuberculosis during pregnancy has occasionally been performed. Hartmann reports a case done at six months which was delivered of a healthy living child at term. Israel also reports a similar case at four months, and Schmidt one at five months. In the latter case the child died of sepsis twelve days later. In spite of these reports it must always be a grave question as to the wisdom of suddenly putting the extra load of doing all the work upon a kidney already embarrassed by pregnancy. Should pregnancy occur, the question as to whether or not it shall be interrupted in any particular case depends upon the conditions already discussed. If any of these are present labor should be induced.

CHAPTER XVI.

STONE IN THE KIDNEY AND URETER.

By HUGH CABOT, M.D.

ETIOLOGY.

The fundamental cause of stone in the kidney is the same as that of stone in the bladder, and for this particular part of the discussion see page 132. On the other hand, there are certain problems involved which should be mentioned.

Infection.—It has been widely believed that infection has played an important part in the formation of calculi. This opinion has perhaps in part been due to the fact that infection and stone are commonly associated but I believe that the infection has no etiological relation. If it were an important cause it should be most effective in those individuals and at that time of life when infection is most common. It should further be most frequent in those types of renal infection which involve chiefly the pelvis. Now pyelonephritis of colon bacillus origin is *the* important infection of the renal pelvis. This is enormously more common in the female than in the male, the proportion being perhaps as high as eight or nine to one. It is extremely common in female children. It occurs with great frequency in women particularly associated with pregnancy, yet it is notorious that stone in the kidney is more common in men than in women and that though stone occurs in children it is not common at the time when renal infections are most frequent. These facts appear to me to sufficiently dispose of infection as a fundamental factor.

Retention.—That some grade of renal retention is an important factor in stone formation may be readily admitted, but that it is *the* important factor must, I think, be denied. Were such the case, stone would be more common in women than in men, since mobility of the kidney sufficient to cause the milder grades of retention is enormously more common in the female. As above noted stone is more common in men, hence this type of renal retention is not the most important factor. That one need not assume abnormalities in order to explain the mechanical basis of stone formation has been clearly shown by our increasing knowledge of the conformation of the renal pelvis, as shown by the injected radiograph. There is always a portion of the renal pelvis, generally the lower calyx, which is considerably below the outlet of the pelvis. The outer or renal wall of the pelvis is rigid, and though the pelvis itself is a contractile muscular structure it can

hardly be assumed to operate in such a way as to completely empty the lower calyx at each contraction. It therefore follows that there is here a resting-place in which a calculus could form without being seriously disturbed.

Age and Sex.—Stone in the kidney is most common during the third and fourth decades, though stone formation is not rare in childhood and exists in the latter half of life. The following table of our own cases[1] seems to correspond pretty accurately with other similar compilations:

First decade, 9.
Second decade, 28.
Third decade, 56.
Fourth decade, 36.
Fifth decade, 14.
Sixth decade, 9.
Seventh decade, 1.

Renal stone is more common in men than in women. Our own figures for 154 cases show 108 men and 46 women. Holland[6] in an analysis of 1603 cases found 985 men and 618 women.

Side Involved.—In our series of 154 cases the right side was involved in 61, the left side in 69, both sides in 24. Analyzed by sex it appears that the right side was more commonly involved in women while the left side was more commonly involved in men. Arcelin[1] in a series of 97 cases found 53 on the right, 34 on the left and 10 bilateral. From this it would not appear that there is any notable disadvantage of one kidney as compared with the other.

PATHOLOGY OF STONE IN THE KIDNEY AND URETER.

It is unnecessary to go into an extended description of the results produced in the kidney by the presence of stone. They are the result of two factors, *obstruction* and *infection* chiefly, though the mere growth of the stone will in and of itself compress and thus destroy kidney tissue.

Obstruction.—Obstruction operates by compressing the renal tissue as a result of obstruction of the outlet. This is more marked with small than with large stones because the former can move in such a way as to cause intermittent obstruction, while at a later stage of growth they become fixed and the kidney accommodates itself to their presence. It is on the whole surprising that stone in the kidney does not cause more damage in this direction than we actually see. In a majority of cases the amount of obstructive damage is comparatively small. The hydronephrosis produced by stone may at any stage become pyonephrosis by the introduction of infecting organisms. In a proportion of cases which cannot be accurately stated, since careful studies of the urine from the kidney are not at hand in sufficient numbers, infection of the renal pelvis, in connection with and perhaps on account

of stone occurs. That the organisms reach the kidney by the ordinary process of excretion seems to us probable as the result of our work upon renal infections. That they may arrive directly by the blood stream through the vessels supplying the renal pelvis is of course possible. *Infection* will follow the type of a pyelitis or a pyonephrosis according to the condition of the kidney when the infection occurs. If there is little or no obstruction the type will be pyelitic, if there is hydronephrosis, pyonephrosis will result. It is probable also that a pyelitis accompanying stone may in and of itself so much increase the thickness and immobility of the renal pelvis as to cause pyonephrosis in quite the same way as it occurs in the cases of long-standing chronic pyelonephritis without stone. Broadly speaking, pyelitis associated with calculus will subside and disappear after removal of the stone, assuming that it does not reform, while pyonephrosis is a permanent lesion from which recovery cannot take place and the kidney must be regarded as of doubtful utility to the patient.

SYMPTOMS OF STONE IN THE KIDNEY AND URETER.

Since the symptoms of renal and ureteral calculi differ to a considerable extent they must be discussed separately.

Renal Calculus.—**Pain.**—While pain of some variety is an exceedingly common symptom of stone in the kidney its entire absence is by no means rare. The so-called "silent stones" form a disquieting proportion of cases which have been discovered by modern methods of diagnosis. While pain in some amount is probably present in 80 per cent. of the cases, it is of slight or unimportant severity in perhaps 30 per cent. In a recent analysis of our cases, pain was the presenting symptom in 33 per cent. and in the balance was so atypical as to suggest other conditions rather than stone. A common type is dull pain referred to the region of the kidney; pure backache is not uncommon, while various vague, fleeting pains frequently occur.

Renal Colic.—This though by no means a characteristic symptom of renal calculus is yet a common one, occurring at some time in nearly half the cases. When typical it consists of a sudden sharp, even severe pain beginning in the region of the kidney, referred to the back rather than to the front and thus often distinguishable from biliary colic. It has a decided tendency to radiate downward along the course of the ureter and to be referred ultimately to the region of the bladder, symphysis or various parts of the genital apparatus. It may, however, radiate downward, being referred to the anterior and occasionally to the posterior aspect of the thigh and more rarely it radiates upward toward the shoulder and if on the right side may be confused with the pain of gall-stones, while on the left it has been mistaken for angina pectoris. An attack of colic may vary greatly in duration from a short, stabbing pain lasting a matter of seconds to the long-continuous grinding ache which may persist for hours. In the worst cases with

more or less intermission it may last for days. The more severe attacks are likely to be accompanied by nausea and vomiting. There is, however, a striking lack of constitutional disturbance in uncomplicated cases. With no infection of the kidney, fever is probably never present, and unless the attack be of unusual duration there is no important alteration of the pulse rate. Patients with stone may have attacks of renal colic at shorter or longer intervals, often several months intervening between the seizures. During and immediately after an attack of renal colic there is almost invariably abnormality of the urine. Marked diminution in the amount of urine is common during the attack but is rarely sufficiently striking to be of diagnostic importance. On the other hand, it is at this time that abnormalities in the character of the urine are most likely to be seen, and it may be doubted whether a strictly normal urine is ever persistently present during and immediately after such an attack. The normal urines which are characteristic of some cases of stone between attacks are rarely seen at this time. Frequency of urination and vesical irritability have often been referred to as a common symptom in renal calculus during an attack. Evidence, however, is accumulating (Braasch) to show that most of these cases are in fact due to stone in the ureter, and I do not feel clear that pure renal calculus produces this symptom.

Silent Stone.—Modern methods of diagnosis have made it abundantly clear that there are a large number of cases of renal calculus which attract no attention on the part of the patient and are discovered accidentally by an examination of the urine for life insurance or for some extraneous purpose. Stones thus discovered are almost invariably of considerable size and it is notable that the larger the stone the less likely it is to cause symptoms, while conversely the little stones, like little dogs, are likely to make the most noise. It is by no means an uncommon observation to find massive bilateral calculi unsuspected by the patient and discovered accidentally by the roentgenologist or the internist when examining for some other condition.

Urine.—Abnormality of the urine is undoubtedly the most common symptom. This abnormality consists in the finding of albumin, pus and blood in varying amounts. One or the other of these is present in at least 85 per cent., albumin is the most constant in our experience, about 80 per cent., while blood and pus were present in about 75 per cent. A persistently normal urine was found in 14 per cent. of our 150 cases and similar observations have been recorded by others. It therefore follows that while abnormality of the urine is of great value when present, normal urine cannot be considered as evidence of the absence of stone. Macroscopic blood, hematuria, is present at some time in many cases but is not often an important guide to diagnosis.

Tumor.—Tumor is not a common result, being found in about 15 per cent. The majority of these cases are those in which pyonephrosis complicates the picture and the tumor is that of a pyonephrotic kidney rather than that of a kidney of renal calculus.

Anuria.—Sudden total anuria may be the first symptom of renal or ureteral calculus. This anuria, whether the first symptom or a later symptom, in patients known to have suffered from stone may occur in one of four ways:

1. The blocking of both ureters practically simultaneously by stone.

2. The blocking of the only ureter. This may occur in cases of solitary kidney, in cases of fused ureter with two kidneys, or in cases where the other kidney has been previously destroyed either with or without the production of symptoms.

3. By the blocking of the ureter of the better of two damaged kidneys with the occurrence of reflex anuria in the damaged kidney on the opposite side.

4. By the blocking of the ureter on one side with reflex suppression on the other side, though the kidney is sound.

There is still considerable discussion as to the possibility of anuria resulting from this fourth accident. Certain it is that the number of cases in which it has been satisfactorily demonstrated has been exceedingly small and in the vast majority of the cases in which it has been asserted to occur more or less disease of the unobstructed kidney has been demonstrated. The characteristic symptom of anuria, is the rapid diminution and final cessation of urine. Pain is generally of the type most often seen in stone in the ureter but may be of the renal type. This symptom often is of moderate amount and after a day or two may cease entirely. A striking peculiarity as yet not satisfactorily explained is the absence of symptoms of uremia, though absolutely no urine reached the bladder. Watson[8] has collected an interesting group of 62 cases in which the average duration of the so-called period of toleration, that is to say, the period without uremic symptoms, was from five to six days. In 14 of these cases the period of toleration was from ten to sixteen days. During this period the patients show absolutely no evidence of the gravity of the situation, and on this account are often allowed to get into an extremely hazardous condition before it is recognized. Anuria must always be regarded as a grave condition and every effort should be made to arrive at an accurate diagnosis and plan proper treatment at the earliest possible moment.

Ureteral Calculus.—In an exceedingly valuable paper Braasch[2] analyzed the findings in 294 cases which we believe to be the most authoritative statement upon this subject. Pain of some variety was present in 98 per cent., showing that this is a much more valuable symptom in ureteral than in renal calculus. This is but what would be expected, since it is difficult for a stone to lodge in the ureter without producing obstruction, the most frequent cause of pain. The other important factor in pain production, as pointed out by Braasch, is the local lesion produced in the ureter by the presence of stone, namely, ulceration. In further analyzing the types of pain he found that in

67 per cent. it was referred to the region of the kidney, that in 15 per cent. it was referred to the upper quadrant, and when on the right might closely simulate gall-stone colic, while in 9 per cent. it was found in the lower quadrants and when on the right side might closely mimic the pain of a grumbling appendix. The pain in the lower quadrants is probably due to the local lesions produced by the stone rather than to the distention of the pelvis and ureter.

Urine.—He found normal urine in 20 per cent. of the cases, an incidence considerably higher than has been claimed for renal calculus. This is entirely consonant with my experience and it is but reasonable to suppose that the lesions produced by stone in the ureter would be less likely to show evidence in the urine than those produced in the renal pelvis. The abnormalities which appear are not very different from those described above under Renal Calculus. He gives an interesting analysis of the position occupied by the stone in this series of cases. In 214 cases it was found in the lower third in 159 cases, 74 per cent., while it was lodged in the upper third including the uretero-pelvic juncture in 54, or 25 per cent., the middle third being the site of the stone in only one case. From this it follows that the surgery of ureteral stone must address itself chiefly to the lower third of the ureter.

DIAGNOSIS OF STONE IN THE KIDNEY AND URETER.

In the diagnosis of stone in the kidney or ureter we must differentiate this condition from infections of the kidney most frequently of the type produced by the colon or the tubercle bacillus, from obstruction to the outflow of urine from any cause, from tumors of the kidney, and finally from a great variety of other conditions producing symptoms which are occasionally mimicked by stone. Of these the most important perhaps are ulcerative conditions of the pyloric end of the stomach and of the duodenum, disease of the gall-bladder and ducts, lesions of the appendix, lesions of the spine, including those of the sacroiliac joint, and lesions of the central nervous system, particularly tabes. This may well appear a formidable list, but certain it is that in each one of these mistakes have been made and that in not a few cases of renal or ureteral calculus useless, because unnecessary, surgical operations have been done. Thus in our small series of 153 cases recently studied at the Massachusetts General Hospital, in 26 abdominal operations had been done elsewhere under a mistaken diagnosis and without benefit.

Physical Examination.—Though it is true that physical examination will rarely be helpful in revealing the presence of stone in kidney or ureter it is of the first importance that it should be carefully and thoroughly carried out, as in no other way can be discovered the possible or probable presence of other lesions which might cause the

symptoms. For example abnormal reflexes will at once suggest the possibility of the crises of tabes while evidence of disease of the stomach or duodenum will give pause to the hasty conclusion that pain in the right upper quadrant is due to renal calculus. Examination of the urine is likely to be first evidence suggestive of stone. This examination should include a study of the sediment, a bacteriological study of the absolutely fresh urine and the estimation of the total renal function with phthalein. It should be remembered that in studying the urine in women no dependence is to be placed upon the findings in the sediment unless the specimen so studied has been obtained with the catheter. Innumerable errors have been made by reporting pus and blood which in fact came from the genital rather than the urinary tract. This statement recalls a patient seen two years ago alleged to be having very frequent and severe attacks of renal colic and to have blood and more or less albumin in the urine. A very cursory examination showed the albumin and blood came from a malignant lesion of the cervix while the so-called colics were the result of a loose sacro-iliac joint which frequently slipped to a slight extent. A few pus cells and a few red blood corpuscles found in urine carefully obtained by catheterization may be of supreme importance, while no amount of pus or blood in a non-catheter specimen is worth serious consideration.

Perhaps the most useful though at times misleading aid to diagnosis is the roentgenogram. The result of such an examination may be one of three conclusions: either positive, negative showing no stone, or showing shadows the nature of which is doubtful. The clearly positive plate may be taken at its face value, though it is proper to note that some confirmation is, as a rule, necessary and that the most expert roentgenologist will occasionally misinterpret a definite shadow, because, unfortunately, he is only human. For several years I have made it a positive rule never to operate for stone in the kidney on the unsupported evidence of the roentgenologist. A negative finding is of interest only as showing that stone did not appear. It is very far from showing that stone is absent, and if the symptoms cannot be satisfactorily explained in some other way, further evidence must be adduced. In a considerable number of cases there will appear in the plate shadows the nature of which is doubtful. Of these the most common are calcified lymphatic glands seen most commonly in the region of the kidney or in relation to that portion of the ureter which lies above the brim of the pelvis, phleboliths found with great frequency in the pelvis, particularly in the neighborhood of the spine of the ischium and consequently in relation to the pelvic ureter, and finally, calcified bloodvessels seen, so to speak, in cross-section. Where shadows of this type lie in the neighborhood of the kidney or ureter and where the signs and symptoms are such as to suggest the possibility of stone their true nature must be definitely demonstrated by further examination.

The Cystoscope.—Of all methods of determining with certainty the presence or absence of stone in the upper urinary tract the cystoscope is the most essential. Its skilful and conscientious use when coupled with the services of an expert roentgenologist should enable a positive diagnosis to be made in every case. The cystoscope in this connection has three functions:

1. For diagnosis. It is essential in the study of cases with a negative roentgenological finding and for the identification of doubtful shadows. By its use can be demonstrated the presence or absence of ureteral obstruction (Figs. 218 and 219), the relation of doubtful shadows to the course of the ureter and to the renal pelvis (Figs. 220 and 221),

Fig. 218.—Showing several shadows in the pelvis, at least two of which might be produced by stone in the ureter.

abnormalities in size, shape, or position of the renal pelvis (Fig. 222). Invisible stones may be discovered by scratch marks on the wax-tip catheter, alterations of function may give the clue to the diagnosis of conditions other than stone which might cause the symptoms, and finally the presence, absence and nature of renal infections can be proved.

2. As an aid in determining the type of operative treatment necessary. The cystoscope is essential to the determination of the functional capacity and condition of a kidney on the side of the stone. It is also essential to the demonstration of the presence and functional capacity of the kidney upon the other side, a fact which must fundamentally influence treatment.

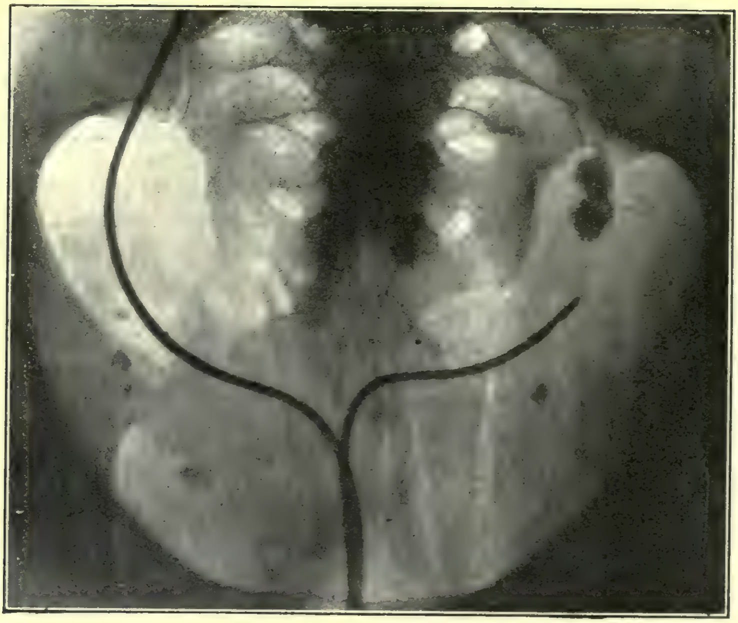

FIG. 219.—Note that the ureter catheter is obstructed on the right side and that the shadow which in Fig. 218 suggests one stone here is clearly produced by two stones. Note also that the small shadow near the right ischial spine lies at some distance from the ureteral catheter, though it might well have been in the ureter.

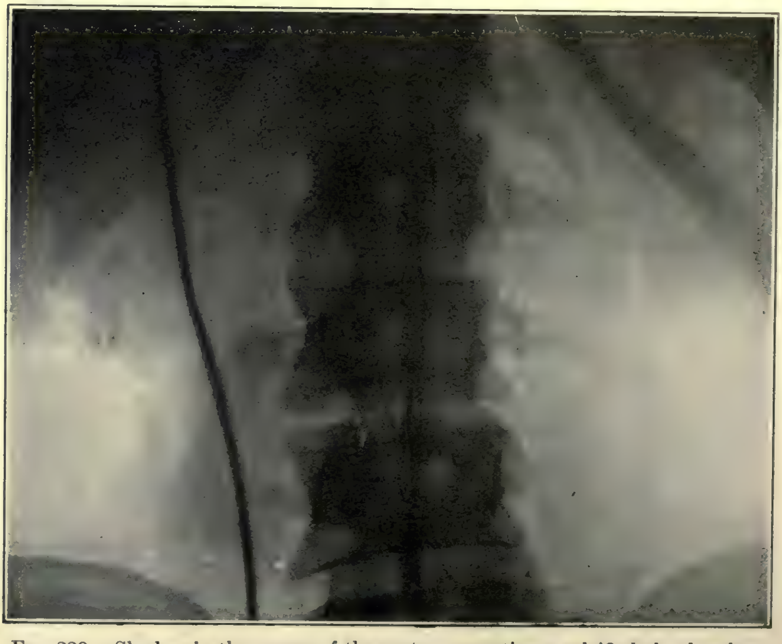

FIG. 220.—Shadow in the course of the ureter suggesting a calcified gland rather than a calculus.

3. As a method of treatment in stone in the ureter. Some stones situated in the lower portion of the ureter may be removed with the operating cystoscope. Stones in portions of the ureter inaccessible to such manipulations may be pushed back and the patient relieved during an attack of colic, also calculus anuria may be temporarily relieved by this method.

FIG. 221.—Injection of the renal pelvis in same patient with argentide shows it to be grossly abnormal.

Method of Cystoscopic Examination.—1. If the roentgenogram is positive. If the plates show the presence of stone in the kidney treatment can only be intelligently planned after a thorough cystoscopic study. Examination of the bladder will commonly show nothing abnormal, though if the kidney be infected mild grades of diffuse cystitis may appear, and the ureter on the affected side may be thickened or puffy. Both ureters should be catheterized, the supposedly sound side in order to show the presence and soundness of the assumed kidney, the diseased side in order to show patency or obstruction of the ureter and arrive at some opinion as to the functional

capacity of that kidney. I have been in the habit of studying function by the use of phthalein and have found it eminently satisfactory. It is advisable to use the intravenous rather than the intramuscular injection, as the time of appearance of the drug is thus considerably shortened and the output doubled during a given length of time. In estimating the kidney function by means of the ureter catheter in these cases two facts should be remembered. As shown by Keyes and Steven the mere presence of a ureter catheter will in some individuals cause inhibition which is apparently reflex, thus notably diminishing the function. This inhibition, however, is apparently equal upon both

FIG. 222.—A renal pelvis abnormal in shape, size and position.

sides and therefore, though the total output of the drug may be diminished, the relative capacity of the kidneys remains the same. If, therefore, the function as obtained in this way is checked up by the total function as studied upon a previous or subsequent occasion a correct opinion will be arrived at as to the renal function of the individual. Great caution should be exercised in drawing conclusions as to the result of phthalein output of a kidney containing a stone. For some reason not clear to me, possibly reflex, the function of these kidneys may be extraordinarily depressed even in the presence of a very large amount of normal kidney tissue. Thus I have repeatedly seen a kidney

whose phthalein function was less than 5 per cent., in half an hour by the intravenous method which two months following the removal of the stone showed a function equal to its fellow on the opposite side, and in all respects normal. As a guide, therefore, to the functional capacity of a kidney thus diseased phthalein is exceedingly uncertain and other and more usual methods of examining the urine will give more reliable evidence. The final decision as to the functional capacity of these kidneys must generally be made at the time of operation. As regards stone in the ureter a cystoscopic examination is particularly valuable as showing the amount of obstruction, whether or not a catheter can be made to pass, and as confirming the evidence of the roentgen ray.

2. If the roentgenogram shows shadows the nature of which is in doubt. In addition to the evidence discussed in the previous section a cystoscopic examination in doubtful cases should concern itself with the relation between the shadows and the kidney pelvis and ureter. For this purpose the so-called radiographic catheter impregnated with some metallic substance is necessary. This passed into the ureter will satisfactorily demonstrate the presence or absence of obstruction and by the taking of stereoscopic plates the relation of the shadows to the course of the ureter. In a small number of cases the ureter may be obstructed by shadow-casting bodies lying outside of it. These are largely glands which, infected with the tubercle bacillus, have undergone caseation and calcification and if they lie in contact with the ureter have become adherent to it, producing more or less compression. These facts may be determined by demonstrating the relation of the shadow to the ureter. If it lies actually in contact with the ureter the injected radiograph, later to be discussed, will show whether or not it is obstructing to the extent of producing dilatation. In this group of doubtful cases the wax-tip catheter, later to be referred to, is occasionally useful. There is a group of cases in which shadows appear in the plate occupying a position which might well be occupied by the renal pelvis. In most of these the radiographic catheter and the evidence of abnormality of the urine from that side will be sufficient to a positive diagnosis. In a few cases, however, there may be honest doubt or difference of opinion and in these the injected radiograph by showing that the shadow does or does not lie within the renal pelvis becomes of importance (Figs. 223 and 224).

3. If the roentgenogram is negative. As already pointed out, negative plates do not exclude stone. Observers of all nationalities and of all shades of opinion agree upon this point, though gross disagreement occurs over the details. Thus the clinician invariably puts the percentage of error higher than does the roentgenologist. The discrepancy is entirely natural since the latter always feels, and quite properly, that in the cases where negative results have been obtained an opportunity for further and more detailed study would have given positive results. It is undoubtedly true that the tendency

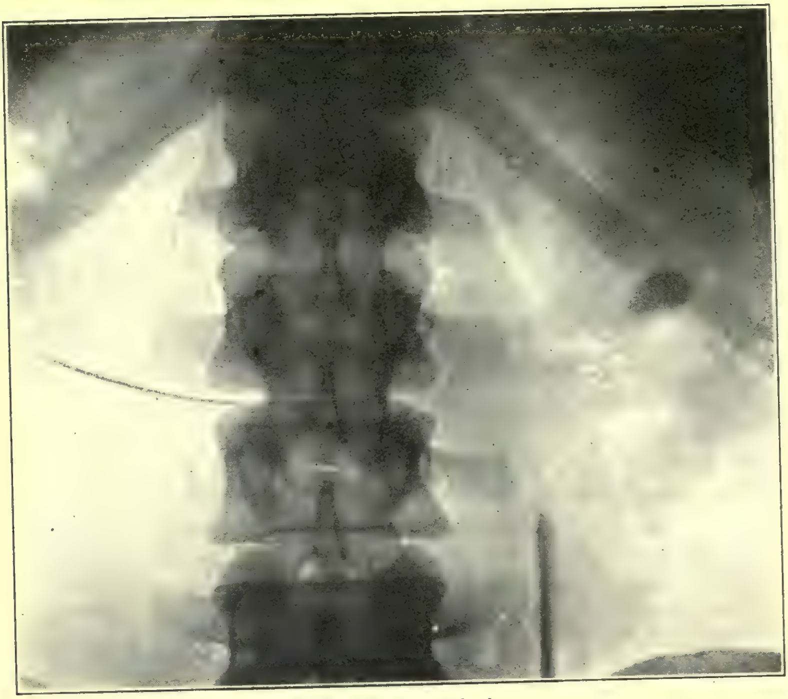

FIG. 223.—Renal calculus.

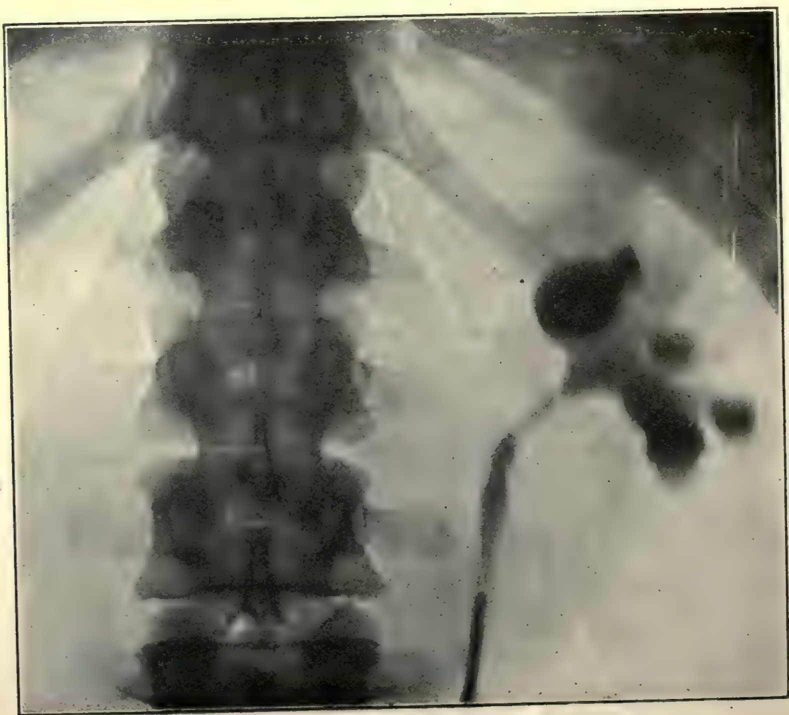

FIG. 224.—Same case injected to show in which calyx the stone lies.

of the clinician to hurry the roentgenologist or to be satisfied with an insufficient amount of evidence has been a large factor in negative results. Be this as it may, the fact remains that in a proportion of cases variously estimated at from 5 to 15 per cent. the plates are negative. Under these circumstances the correct diagnosis rests well upon the evidence obtainable by the cystoscope. Other lesions, notably infections, chiefly with the colon and tubercle bacillus, must be identified or excluded. Freedom of the ureter from obstruction is of value but does not prove stone absent, since in a small proportion of cases stones in the ureter do not obstruct the catheter to any notable degree. This is particularly true of those which lie at the ureterovesical junction, where a pouch apparently forms somewhat similar to that seen in the urethra in front of the triangular ligament. In this pouch stones lie secure either from expulsion or from discovery by the unaided catheter. The use of a wax-tip catheter in the diagnosis of renal and urethral stone was introduced by Kelly in 1894. As described by him it was limited in its application to women in whom it can be employed through the open cystoscope. Later its utility for use through the ordinary cystoscope was pointed out. So far as I am aware the credit for this belongs to Harris, and more recently ingenious methods have been described by Hinman and by Kirkendall.[7] Harris's method consists in passing the ureter catheter properly tipped with wax to the bladder and allowing the distal three or four inches to curl up within that viscus. Over this the cystoscope is threaded in such a way as not to scratch the waxed portion. When the cystoscope is in place the catheter is withdrawn, keeping the wax tip always in view until it arrives at such a position that it can be passed into the ureter. Hinman's and Kirkendall's methods substitute the use of a rubber sheath passed through the cystoscope and seem satisfactory modifications. The whole principle of the wax-tip catheter turns upon the fact that the wax is scratched by contact with the stone and that these scratches are characteristic when studied with a lens. In the doubtful cases in this group it is a highly satisfactory method and its more universal employment will undoubtedly diminish the number of cases in which the stone, though present, is overlooked.

In this group also the injected radiogram has an important place. By this method alone can be demonstrated normality or abnormality in size, shape and position of the renal pelvis and abnormalities of the ureter (Figs. 225 and 226). It was originally described by Voelker and Joseph but the greater part of our knowledge on the subject has been derived from the researches of Braasch. A considerable variety of soluble silver salts were at first employed, of which collargol appeared to be the most satisfactory. This salt, however, has fallen properly into disrepute because of its tendency to damage the kidney. Being a soluble salt it penetrates the kidney, reaches the capsule and even invades the perinephric fat tissue. I have no hesitation in saying that its use should be definitely abandoned. To overcome these

objections two other preparations have been introduced: a solution of thorium worked out by Burns, and a suspension of silver iodide in quince-seed emulsion worked out by E. L. Young, Jr., and Godsoe. With the use of thorium I am less familiar than with the preparation of Young and Godsoe. From the experience at hand thorium solution appears to be satisfactory, though some difficulty has been experienced in keeping on hand a sterile solution. The iodide emulsion I know from a large experience to be safe and satisfactory.

FIG. 225.—Shows a kidney with entirely separate pelves and ureters. Pelves are injected. Together with Fig. 226 is shown how the ureter from the upper pelvis crosses the second ureter and empties nearer the urethral opening than the one from the lower pelvis.

Before making the injection it is wise to ascertain the capacity of the renal pelvis in order to avoid overdistention or, equally important, that a hydronephrotic kidney may be supplied with enough injecting fluid to give a satisfactory picture. The injections should be made slowly, not going beyond the point of slight discomfort to the patient

and the distending fluid should, so far as possible, be withdrawn and the kidney pelvis be washed out after plates have been taken.

By this method abnormalities of the renal pelvis produced by lesions other than stone will be clearly shown (Figs. 227, 228 and 229). A moderate degree of dilatation due to stone will at once appear and in some cases at least in which collargol or silver iodide was used the stone previously invisible becomes at once apparent.

Fig. 226.—Same patient as Fig. 225.

Finally, in this group of cases with a negative roentgenogram the study of renal function will often give evidence which will lead to a correct opinion. For instance, if the function of the kidneys is equal and normal and no other abnormality can be found, it is safe to conclude that stone in the kidney is not present. On the other hand, gross abnormality of function on the side causing the symptoms must be explained either by stone or by some other process competent to produce it.

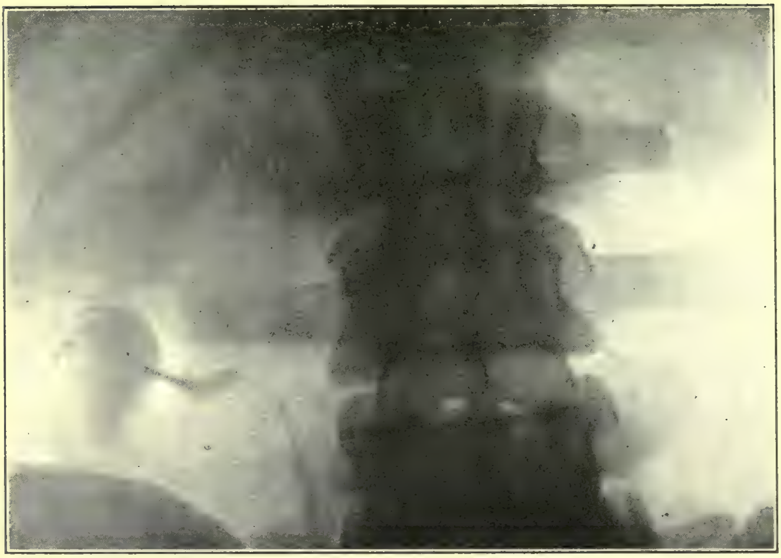

FIG. 227.—Injected radiograph in a case of hypernephroma.

FIG. 228.—Outlines of renal pelvis in a case of inoperable hypernephroma.

Other Methods of Diagnosis.—The other methods of diagnosis which must be utilized in cases in which the question of stone in kidney or ureter has been raised are those suitable to the other conditions with which renal calculus is occasionally confused. Thus there is a considerable group of cases of pain in the upper right quadrant, colicky in character, coming at longer or shorter intervals, occasionally associated with nausea and vomiting, in which it is of the first impor-

Fig. 229.—Showing form of renal pelvis in a case of congenital polycystic kidney.

tance to exclude, so far as possible, stone in the gall-bladder or common duct and ulcer of the stomach or duodenum. In these cases the study proper to the kidney may yet fail of a satisfactory diagnosis until these other conditions have either been proved present or absent. Thus where the right kidney shows a mild grade of pyelitis with slight dilatation of the renal pelvis and the evidence of stone is negative in other respects it is well to remember that the symptoms may be produced by gall-stone, and the signs found in the urine bé an accidental

coincidence. X-ray and the fluoroscopic study of the stomach and duodenum after a bismuth meal will generally enable a positive diagnosis to be made. For the same reasons where the pain of ureteral calculus is referred to the lower right quadrant of the abdomen confusion with chronic appendicitis will frequently occur unless careful study of the intestinal tract after a bismuth meal be faithfully carried out. Confusion here is of course most likely to occur in that not inconsiderable group of cases of ureteral calculus with a normal urine.

Relaxation of the sacro-iliac joint leading to attacks of pain which not infrequently radiate along the course of the sciatic or occasionally anterior crural nerve and various lesions of the lumbar spine must be carefully considered and systematically excluded. A few cases have come to our notice in which abnormalities of the transverse process of the fifth lumbar vertebra, by which it impinged upon the adjacent ilium, have given rise to symptoms which have been mistaken for renal colic.

Various forms of cerebrospinal syphilis, particularly of the type of tabes which result in attacks of pain referred to the region of the abdomen, have been a disastrous source of confusion. Such a mistake can only be avoided with certainty by a careful study of the reflexes, of the Wassermann reaction of the blood and a searching investigation of the spinal fluid including the Wassermann reaction.

Diagnosis of Calculus Anuria.—Calculus anuria must be distinguished from the anuria seen in hysterical patients and from the high degrees of oliguria closely approaching anuria which occur in certain acute conditions of the kidney most commonly after the ingestion of metallic poisons, but occasionally in acute nephritis and occasionally in acute septic infections. There is little danger of serious confusion arising except in the hysterical cases. These may absolutely mimic calculus anuria and can be distinguished only by a satisfactory demonstration of the absence of ureteral obstruction. Pain may be of exactly the same type in either hysterical or obstructive anuria. On the other hand, fever is common in hysteria, uncommon in the obstructive type. The urine may give a clue, as in the hysterical cases what urine is passed will be normal, whereas in the calculus cases it will be abnormal. The cystoscopic study should show an entire absence of obstruction or other abnormality in the hysterical cases, while in those due to calculus definite obstruction should be demonstrable upon one or both sides.

If this obstruction can be even partially overcome, urine will reach the bladder. It is to be remembered that obstructive anuria may be due to blocking of the ureter by what seem like insignificant calculi or even by blood clots. I have elsewhere reported a case in which both ureters were obstructed and total anuria followed in a case of bilateral hematuria due to colon bacillus pyelonephritis.[3] In this case catheterization of the ureters was at once followed by expulsion

of the obstructing material and function was restored to normal. In calculus anuria only one side may show evidence of obstruction and if this obstruction be proved to be due to a calculus nothing more is necessary to the diagnosis. In most cases of obstructive anuria calculus can be demonstrated by the roentgenogram and where this evidence is negative hysteria may well be suspected.

TREATMENT OF STONE IN THE KIDNEY.

No time need be spent in discussing the treatment of stone in the kidney by drugs or other methods looking to the solution of the calculus. Such methods, though much to be desired, are at present wholly mythical.

Treatment of Renal Colic.—Where a patient is seen during an attack of renal colic he and therefore the surgeon is more concerned with the colic than with the accurate diagnosis of the underlying condition. Where the colic is of the commoner type of comparatively brief duration morphin freely given hyperdermically is generally the only efficient and necessary measure. Heat generously applied, preferably in the form of flaxseed poultice, is of some benefit. Should the attack fail to subside, or having subsided should it promptly recur, an attempt should be made to relieve the obstruction by the use of the cystoscope and ureter catheter. By this means in many cases the stone can either be pushed back if it lies in the upper portion of the ureter or a bougie-pointed catheter can be insinuated between the wall of the ureter and stone and finally made to pass, thus relieving the pressure upon the renal pelvis and ureter. Such measures are of course purely temporary but will tide the patient over the attack and give time for a systematic study upon which alone satisfactory treatment can be based.

Treatment of Unilateral Renal Calculus.—Unilateral calculi may be divided into three classes for the purpose of treatment:

1. Calculus pyonephrosis.
2. Renal calculi too large to pass.
    (*a*) With infection of the renal pelvis.
    (*b*) Without infection of the renal pelvis.
3. Small stones which under favorable conditions might be passed.
    (*a*) With infection of the renal pelvis.
    (*b*) Without infection of the renal pelvis.

1. **Calculus Pyonephrosis.**—The treatment of calculus pyonephrosis is nephrectomy, this assuming that the condition of the patient is such as to warrant any severe operation. The integrity or substantial integrity of the kidney on the other side must always be demonstrated but no method of treatment short of nephrectomy stands any chance of benefiting the patient. There are some cases of large silent stone which has caused pyonephrosis occurring in patients late in life in whom on account of their age and the absence of symptoms other

than pyuria no operation is indicated. In early or middle life, on the other hand, there are few cases in which the patient should not be urged to part with his damaged and unprofitable kidney.

2. **Stone too Large to Pass.**—In this group are included the great majority of unilateral renal calculi. They will vary from the pelvic stone half an inch in diameter to the large branched calculi filling the pelvis and calices and encroaching considerably upon the kidney tissue. As a general rule these should be removed since they are certain sooner or later to completely destroy the kidney and in most cases are a source of recurrent discomfort to the patient. If the renal pelvis is as yet uninfected this constitutes an additional argument in favor of operation, since the probability of infection is large and when this occurs the damage to the kidney goes on more rapidly, and should alkaline decomposition occur, the growth of the stone may take on a new lease of life. Some question may arise as to the wisdom of advising operation in the cases which are discovered more or less accidentally and which have been a source of no discomfort to the patient. While this often makes it more difficult to convince the individual that he ought to subject himself to a trying ordeal it is, on the other hand, no argument in favor of withholding operation. The absence of symptoms is of course evidence that obstruction has not occurred and to this extent progressive damage to the kidney will go on more slowly. On the other hand, it may be stated dogmatically that a calculus too large to pass is incompatible with the continued integrity of the kidney, that infection with the great probability of producing symptoms will almost inevitably take place, and that in the long run avoidance of operation probably means the sacrifice of the kidney. Where the kidney is already infected no hope can be held out that this infection will disappear until the calculus is removed, and though patients commonly exhibit a high grade of toleration of the chronic, commonly colon bacillus, pyelitis seen in these cases, it cannot be regarded as a harmless amusement. Unless, therefore, there exist some lesion elsewhere in the body making operation unusually hazardous it may unhesitatingly be advised, assuming always that the kidney on the other side is reasonably sound.

3. **Small Stones.**—The small unilateral renal calculus raises the most difficult questions in regard to the propriety of operative treatment. It is difficult to decide precisely how large a stone must be to warrant one in declaring that it cannot be passed through the ureter. Certain it is that surprisingly large stones do pass in spite of expressed opinion to the contrary. The decision for or against operation should be made upon the evidence of the amount of damage which the stone is doing. Thus small stones lying quietly in the lower calyx not producing colic and unaccompanied by infection may be allowed to remain (Fig. 230). These cases should be followed carefully at intervals of six to twelve months by means of the roentgenogram. If they show a distinct tendency to grow, operation may be advised, while if they remain

of substantially the same size a Fabian policy is advisable. I well remember the case of a colleague whose urine was accidentally discovered to contain a trace of albumin, a little microscopic pus and blood. A small calculus was discovered lying in the lower calyx and as it produced no symptoms operation was not advised. Six years later he died suddenly from other causes and at autopsy a stone corresponding exactly to that seen in the plates at the time of the original examination was found lying in the lower calyx. In other respects this kidney was practically normal.

Fig. 230.—Small stone lying in the middle calyx.

Infection should be considered in this connection. The uninfected, comparatively silent stone may wisely be let alone while the stone in an infected pelvis is clearly objectionable, and should it show no tendency to pass should generally be removed. In this group of cases, however, it is proper to defer to the wishes of the patient and correspondingly unwise to strongly urge operation for conditions which are not of themselves immediately dangerous. If at any time silent

stone begins to produce symptoms, if it shows a tendency to grow, if infection supervenes, or if the patient begins to fret over the condition, operation may be at once undertaken.

FIG. 231.—Bilateral renal calculi. The one on the left is recurrent and the kidney is now almost destroyed, as suggested by other scattered stones.

Bilateral Renal Calculus.—The treatment of this condition may properly be considered under four headings:

1. Large calculi in both kidneys.
   (*a*) Infected.
   (*b*) Uninfected.
2. Large calculus on one side, small calculus on the other.
   (*a*) Infected.
   (*b*) Uninfected.
3. Calculi of moderate size on both sides.
   (*a*) Infected.
   (*b*) Uninfected.
4. Small calculi on both sides.
   (*a*) Infected.
   (*b*) Uninfected.

1. Bilateral calculi obviously raise a more difficult question than unilateral calculi partly because they offer a more difficult operative problem and partly because they are a far more serious menace to the life of the patient who might be said to be more or less constantly balanced upon the verge of calculus anuria. Where the stones are large upon both sides it may be presumed that the amount of damage to the kidneys is extensive, but unfortunately, as previously pointed out, it is difficult to determine the amount of sound kidney tissue by any tests

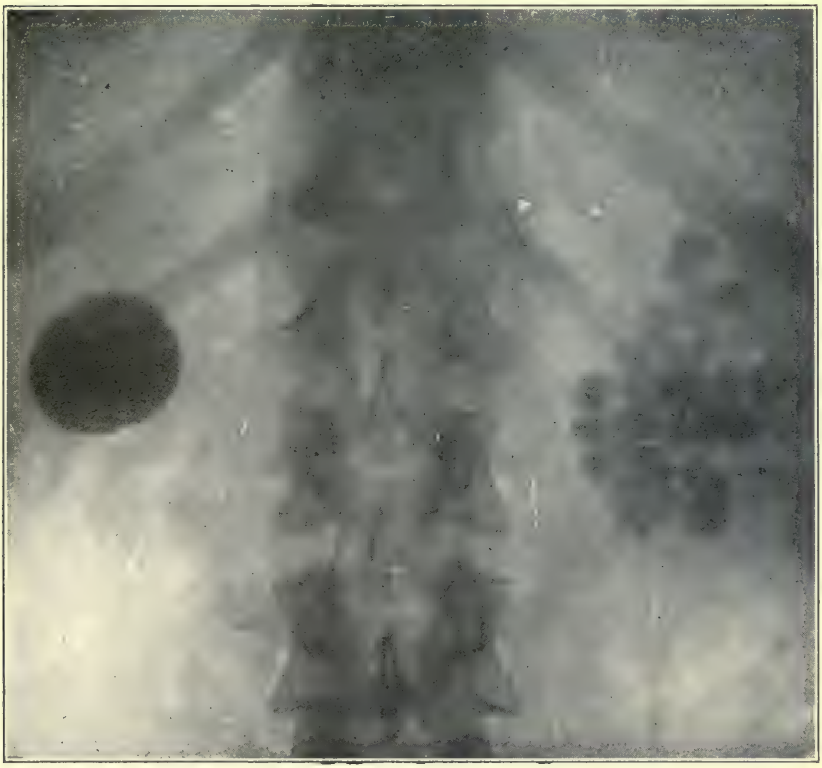

FIG. 232.—Bilateral renal calculi. The shadows on the right resemble gall-stones.

at our disposal (Fig. 231). This condition will be found perhaps most commonly in patients past middle life and under these circumstances the surgeon may well hesitate to advise operation. Many of them get along without much discomfort, would undoubtedly have to accept a large operative risk, and may survive for many years without operation. Should anuria occur the risk is not much increased if no delay supervenes. On the other hand, in early or middle life the probability is considerable that the patient's life can be much prolonged by successful operation and if he is in other respects sound it may properly be undertaken (Figs. 232 and 233). If infection has not occurred the

operative mortality will be considerably less, partly because of the absence of perinephritic adhesions and consequent shortening of the

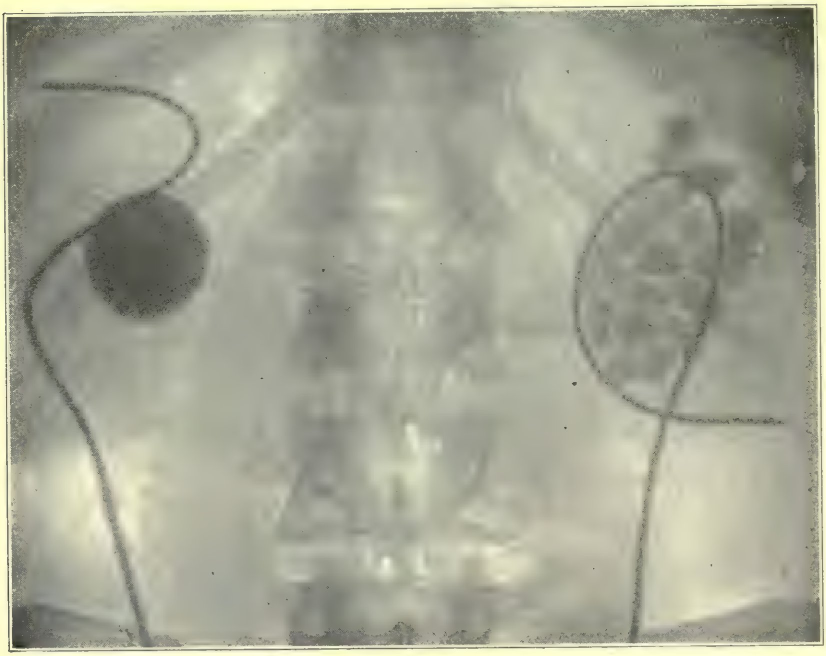

FIG. 233.—Same case as Fig. 232, showing x-ray catheters in the kidney pelves, proving that the shadows are in kidney and not gall-bladder.

FIG. 234.—Bilateral calculi. In this case the worst side was operated upon first.

time of operation and partly because the injury to the kidney inevitable as part of the operation will not be increased by the presence of suppuration. The decision will ultimately turn upon the age and general condition of the patient, the younger and sounder individuals giving, of course, better results.

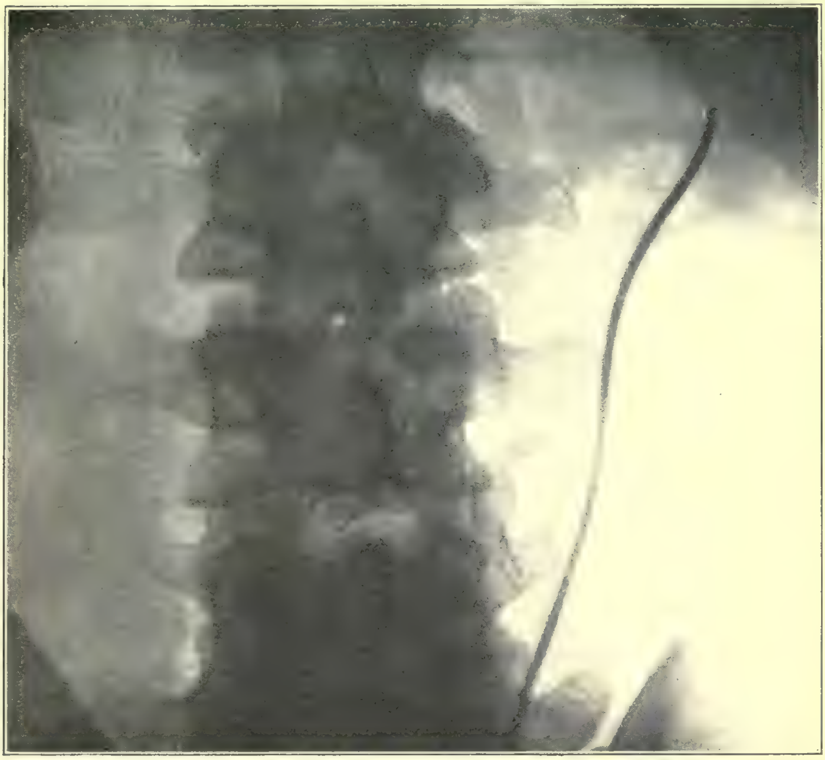

FIG. 235.—Same case as Fig. 234 after first operation. Note the small shadow near the transverse process of the third lumbar vertebra on the right. This was suspected of being a ureteral calculus but its variable position and distance from the catheter exclude this possibility and suggest a mesenteric gland. The stone in the left kidney was removed just after the plate was taken.

2. A less difficult decision is presented when there is a large calculus on one side and a small calculus on the other (Figs. 234 and 235). The small stone should in the great majority of cases be promptly removed in order to prevent, if possible, progressive damage to that kidney. Particularly is this true if the kidney containing the large calculus is extensively damaged and the small stone is likely to become engaged in such a way as entirely to obstruct that kidney, as under these conditions anuria will promptly result. These patients are in considerably more danger of this complication than are those with large calculi on both sides. Whether operation should be advised

upon both kidneys will depend largely upon the condition of the worst side. If this has been extensively destroyed, is producing no symptoms and is therefore doing neither good nor harm it may perhaps be disregarded. On the other hand, if though the stone is large the kidney is still good and particularly if it is uninfected operation should generally be undertaken.

3. Where both kidneys are the site of stones of moderate size operation for their removal should as a rule be advised. Anuria is a more or less constant menace, progressive damage to the kidneys practically certain, operation is not particularly hazardous and the outlook for restoration of kidney function is good. Infection of degrees short of pyonephrosis will affect the decision but little, though so far as it goes it operates to favor intervention.

4. Small stones of a size which might pass in both kidneys. Except for the fact that anuria is always in the background the situation of these patients is not importantly different from those having small stones in one kidney. The possibility that they may pass is considerable, the chance that they may remain quiescent and do no damage is not to be overlooked, and probably in the majority of cases they do pass ultimately in a satisfactory manner. I believe it is quite permissible to postpone operation, to follow the growth by careful roentgenograms, being prepared at any time to remove the stones should they grow, should the kidneys become infected, or should they cause obstruction on one side. If, though such stones do not increase to a notable extent, attacks of colic occur with greater frequency, operation should not be delayed.

TREATMENT OF URETERAL CALCULI.

Unilateral Ureteral Calculi.—Less difficulty, as a rule, surrounds the decision for or against operation in ureteral calculi. By their very presence in the ureter they are a constant menace to the integrity of the kidney, the exception being those cases of small stone lodged in a pouch of the ureterovesical junction which apparently maintain this position for long periods of time without causing obstruction. A calculus in the ureter which is making progress may be allowed to proceed if it does not consume an inordinate amount of time. When, however, it comes to rest without having been expelled into the bladder its presence cannot be regarded as harmless. If it can be removed by measures short of operation, such as manipulation with the ureter catheter or by the operating cystoscope, this should of course be preferred, but this is applicable chiefly to stones in the lowest portion of the ureter and particularly those in the intramural portion of the ureter, and is likely to be unsuccessful for calculi caught at a higher level. Unless there is strong contra-indication ureteral calculi which are not making progress should be removed.

Bilateral Ureteral Calculi.—Calculi may exist in both ureters at the same time without causing anuria. That this accident is always imminent is obvious, and there are few conditions under which operation can safely be avoided. As a rule delay is the more disastrous alternative of the two.

RENAL AND URETERAL CALCULI.

In this condition there are two possible combinations:

1. Stone in the kidney on one side and in the ureter on the other.
2. Stone in the kidney and ureter on the same side.

1. Where stone exists in the kidney on one side and ureter on the other the danger of anuria is only slightly less than where the stones lie in both ureters. The indications for operation are practically the same as those just discussed and only serious contra-indications warrant the avoidance of operation.

2. Where stone occurs in the kidney and ureter upon the same side operation is to be advised except in those cases where the destruction of the kidney has been excessive and the situation is practically that of a calculus pyonephrosis on one side, previously discussed. If the kidney is sufficiently sound to be of value to the patient the ureteral calculus at least should be removed. Since the chances favor the calculus lying in the lower third of the ureter operation for the removal of both the ureteral and renal stone must obviously be pretty extensive. The obstruction of the ureter is the most urgent condition and in a considerable number of cases at least this should be done first and the renal calculus allowed to pass if it will or removed later if it will not.

Operative Treatment.—**Renal Calculi.**—Three operations are or may be appropriate for this condition, namely:

1. Nephrectomy.
2. Nephrotomy, partial or complete.
3. Pyelotomy.

NEPHRECTOMY.—Nephrectomy is indicated only in cases where the destruction of the kidney is so complete that it is of no value to the patient and only a menace. Practically these conditions exist only in calculus pyonephrosis, and though nephrectomy has been done many times upon kidneys containing large calculi or even calculi not so large, serious doubts may be entertained as to whether these kidneys were not still of some value to the patient and should not, therefore, have been allowed to remain. There are a few cases in which following nephrotomy, nephrectomy becomes necessary but this group will be later discussed under the heading of Nephrotomy. That nephrectomy should be done only where absolutely indicated is a proposition that need not be extensively discussed. Clearly a patient who has had a calculus upon one side is more likely to have the same condition develop

upon the other side than is a normal individual, and he is therefore doubly in need of two kidneys.

Operation.—As a rule nephrectomy for pyonephrosis is among the more difficult operations upon the kidney. This difficulty arises from the amount of perinephritis inflammation with the consequent tying of the kidney through its fat capsule to the surrounding structures. Furthermore, the pedicle is likely to be thick, stiff and short on account of the infiltration of the surrounding fat tissue by the renal infection. The position of the patient upon the table is the same as that most useful in nephrectomy for tuberculosis and is described and illustrated by Dr. O'Neil on page 532, Fig. 209.

For this, as for all other operations upon the kidney for stone, we have found the oblique incision, just below the border of the twelfth rib and extending from the anterior border of the sacrospinalis forward and downward parallel to the lower border of the twelfth rib to a point generally about two inches to the inner side of the anterior superior spine of the ilium, to be the most useful. This incision seems to us superior to the more vertical incision advocated by Mayo and entirely superior to the old truly vertical incision now largely abandoned. Through this incision we have been able to deal with all the problems presented in the kidney by renal calculus. The extent to which the kidney is fixed to the surrounding tissues will vary largely with the age of the process. In some long-standing cases having a duration up to a quarter of a century, the kidney is literally plastered to the muscles and the peritoneum is practically incorporated with the anterior layer of the fat capsule. Under these circumstances a slow, painstaking dissection through an incision of sufficient length is generally necessary. Not infrequently in spite of every precaution, the peritoneum is torn, but this accident does not seem to us serious provided it is recognized. Where a small rent in the peritoneum is overlooked and not guarded by walling-off gauze it is entirely possible that septic material may be spilled, and as the patient is in a position favoring its entrance into the peritoneal cavity widely diffuse peritonitis occasionally results. If the accident is recognized it is, as a rule, best to protect the peritoneal cavity with gauze rather than to attempt its immediate closure by suture, as should this be done, another tear may well take place at a later stage in the operation. The most troublesome, though as a rule not the most dense adhesions occur about the upper pole, the difficulty lying in their inaccessible position and the fear of tearing the peritoneum at a point where it cannot readily be sutured. Most of the dissection must be carried out with the fingers and under control of the sense of touch rather than of sight. In some advanced cases the size of the tumor may be very considerable and its bulk may consist largely of fluid. Under these circumstances the surgeon is under a considerable temptation to diminish the size of the tumor before the kidney has been freed from its bed. This has seemed to me ill-advised, as it is easier to free the tumor while it is

still tense than after it has become a more or less lax sac. We have therefore followed the practice of freeing the kidney as much as possible, then if it is large and if its bulk can be considerably diminished by evacuating its contents, this should unhesitatingly be done. The fear of wound contamination we believe to be exaggerated, as the organism involved is generally a variety of the colon bacillus relatively non-pathogenic and very rarely giving rise to wound suppuration. Since these cases as a rule require some drainage of the wound, healing is not jeopardized by the temporary soiling due to emptying the tumor. In cases with a short pedicle and much peripyelitis the approach to the pedicle is often rendered easier by dividing the ureter at a point some distance below the kidney and freeing it up to the pelvis, thus enabling the surgeon to separate the pelvis from the vessels lying in front of it and thus much diminish the size of the pedicle. When the kidney has been freed to the fullest extent and the ureter and lower portion of the pelvis separated from the vessels, the clamp should be applied. Though there may be some cases of nephrectomy for other conditions in which it is advisable to attempt to ligature the vessels separately in the pedicle before the application of a clamp, these conditions do not obtain in nephrectomy for pyonephrosis. The amount of inflammatory tissue is such that an attempt to separate the vessels is a highly risky business more likely to result in tearing the vein than in anything else. The clamp should be applied from above and behind rather than from below and in front, this because the renal artery lies nearer the upper than the lower border of the pedicle and the possibility of its slipping from the clamp is thus eliminated. Where the pedicle is broad and barely or not completely grasped between the jaws of the clamp another generally smaller clamp should be applied from below and in front so that its point overlaps the point of the upper clamp. In this way the possibility of slipping of the clamp is entirely avoided. When the clamp or clamps have been satisfactorily adjusted as far away from the kidney pelvis as the shortness of the pedicle will allow, the kidney should be cut away and removed, taking care not to leave any portion of the pelvis as a part of the pedicle. With the kidney out of the way the vessels of the pedicle projecting through the jaws of the clamp may be picked up separately in small forceps and tied. The artery or arteries can in this way always be secured, and as a rule the separate branches of the vein, though this being thin-walled, is less easy of detection in a thick infiltrated pedicle. After all discoverable vessels in the pedicle have been tied in front of the clamp, a catgut ligature should be thrown around the whole mass behind the clamps and pulled taut. The clamp or clamps should then be loosened while tension is kept upon the tie which puckers together the whole of the pedicle, and though its presence is often unnecessary it gives an unobjectionable sense of security. Unabsorbable material for ligature in these cases seems to us objectionable, as there is always necessity for drainage of the wound

and therefore ample opportunity for sinus formation if silk or kindred material has been employed. With a good exposure, proper application of the clamps, and ligature of the vessels, in front of the clamp, it is unnecessary to use the heavy silk ties which in former days were regarded as essential. After the pedicle has been satisfactorily dealt with any injury to the peritoneum should be carefully repaired and the wound then closed in layers with catgut sutures. An attempt to restore the muscular planes of this region by suture of the separate muscles to each other has not proved satisfactory. Sutures in muscle tissue readily tear loose and a ragged wound is the only probable result. On the other hand, there are two strong layers of fascia, one on the inner and one on the outer surface of these great muscle planes. If a layer of catgut sutures is applied to the inner group of muscles, carefully including this fascia and about half of the overlying muscles, satisfactory deep approximation will be obtained. It is in the application of this deep layer of sutures that the trunks of the iliohypogastric or the ilio-inguinal nerve are occasionally caught. At this point the former lies just beneath the deep fascia close to the twelfth rib at the posterior angle of the wound, while the latter is at a lower level and will not be seen in most cases. The position of these nerves must be ascertained before the sutures are applied. A similar suture applied to the superficial layer and also including the outer layer of fascia will give a strong wound with few if any gaping holes between the muscle bundles. Drainage should as a rule be used—a small piece of rubber or protective tissue brought out at the upper and posterior angle of the wound has seemed to us satisfactory. Its deeper end lies in the region of the pedicle. Theoretically these drains should be brought out at the lower angle of the wound, but this has seemed more inconvenient to the patient and has not been notably more efficient.

Subcapsular Nephrectomy.—In calculus pyonephrosis there are a few cases in which the fat capsule of the kidney is so thoroughly incorporated with the surrounding tissues on the one side and the true capsule on the other that its removal is practically impossible. Under these circumstances it may be necessary to use the line of cleavage between the kidney and the true capsule rather than undertake a difficult tedious operation with the probability of considerable damage to surrounding tissues. Subcapsular nephrectomy is at best an unsatisfactory operation. There is practically no pedicle, and the pelvis is almost inevitably included in the clamp, which must, in fact, be applied more or less to the kidney tissue. This can to some extent be remedied by the freeing of the ureter and the separation of the pelvis from the fat capsule around the lower pole of the kidney. The great danger in these cases is that the clamp will cut through the tissue and that bleeding will take place behind it. On the other hand, in these extensively destroyed kidneys the blood supply is, as a rule, small, a condition distinctly comforting at the moment when the clamp compresses the fat pedicle and threatens to cut itself loose. Though

always fearful that accidents would occur, they have not done so in my hands. This operation is further unsatisfactory in that it leaves behind a thickened, always more or less infected fat capsule which must inevitably prolong the drainage from the wound and occasionally result in sinuses of more or less duration. It should never be adopted as an operation of election but may be forced upon the surgeon as one of necessity.

Accidents.—Opening of the Pleural Cavity.—Though this accident is not notably more likely to happen in nephrectomy undertaken for this purpose than in other types of nephrectomy, it may as well be mentioned here for the sake of completeness. It depends upon the fact that in not a few cases the twelfth rib is so short as to be overlooked or regarded as the transverse process of the first lumbar vertebra. Under these circumstances the incision may be made parallel to the border of the eleventh instead of the twelfth rib. As the incision is prolonged backward, the pleural cavity which always comes down to the middle of the space between the eleventh and twelfth ribs, and generally to the upper border of the twelfth rib, will inevitably be opened. The accident is, as a rule, at once recognized by the peculiar hissing sound made by the entrance of air into the pleural cavity. Occasionally collapse of the lung produces troublesome embarrassment of respiration, as the lung which must actually do the bulk of the work is more or less compressed by the weight of the patient. Should respiration become irregular, and particularly should the action of the heart be to any extent embarrassed, the operation should be suspended or abandoned and the patient turned upon his back so as to disembarrass the remaining lung. This accident is, however, rarely of troublesome consequence, and, as a rule, if the opening in the pleural cavity be promptly closed the operation may be continued and finished without paying any further attention to the condition. One would suppose that this was an accident more likely to happen to the novice rather than to the experienced surgeon. I suspect, however, that this is not the case, as within the last six months it has happened to me twice within one week while my total record for this accident is only 5 in over 300 cases. It can, I believe, always be avoided if care be taken to identify with certainty the twelfth rib. If this is short the fact should have been observed in the radiogram taken previous to operation, and should not be left to be discovered at the time of operation. It is generally stated in the literature that this accident has practically no undesirable consequences, and whether this be true or not will depend upon what one regards as undesirable. (Martin.) It is certainly rarely followed by empyema, and in time the lung inevitably returns to its normal position. On the other hand, this return to normal is not always a prompt process, and it is by no means easy to determine when it has taken place by the ordinary methods of auscultation and percussion. Thus I have seen two patients in whom this accident occurred and was not recognized until, when the patient

began to be out of bed, an unexplained dyspnea led to a radiogram of the chest, which showed the lung still practically completely collapsed. I do not know of any statistics of sufficient size to warrant accurate conclusions, but in the small number of cases which I have seen the expansion of the lung has generally occupied a period of two or three weeks before it was complete. This will operate only as a mild delay of convalescence, but warrants caution in urging these patients to take up their regular occupation. The question arises whether it is desirable to attempt to remove the air from the chest by sucking it out under pressure. This procedure is probably generally unnecessary, but is unobjectionable, and may be advised wherever delay beyond a reasonable time takes place. It is generally sufficient to aspirate the chest with a needle attached to a suction apparatus and connected up in such a way that the tube from the chest leads into water. In this way the air withdrawn can be seen to bubble through the water, and when negative pressure has been obtained within the chest the water in the bottle will tend to rise in the tube and the needle may then be withdrawn. The effect of this aspiration is apparently to alter conditions within the chest so as to accelerate the absorption of the air. It is not probable that the air is completely or even largely withdrawn. An accurate opinion as to the extent to which the expansion of the lung has proceeded can only be formed upon the basis of radiographic plates or fluoroscopic observations, and reliance should not be placed upon auscultation and percussion.

Injury to the Intestines.—It is in this type of difficult nephrectomy that injury to the intestines is most likely to occur. This takes place, of course, in the process of separating the anterior surface of the fat capsule from the peritoneal cavity. Three portions of the intestines are alone likely to be injured, namely, the overlying portions of the ascending or descending colon, and in the case of the right kidney the second portion of the duodenum. This latter injury must be rare, but an interesting group of such observations has been reported by Mayo, a most comforting observation, since if it can happen in the hands of so expert a surgeon it may well be pardoned to the rest of us. As a rule, such injuries to the intestine, if recognized, are unimportant, as prompt closure with careful sutures is generally quite sufficient. Occasionally, but in our experience exclusively in the cases in which the damage had been unrecognized, fecal fistula will result. As a rule these fistulæ, when of the large intestine, will close spontaneously. The injury of the duodenum must always be regarded as a serious accident, as the action of the intestinal contents is highly corrosive, not to say digestive, and plays havoc with the wound.

After-treatment.—The after-treatment of these cases is, as a rule, easy as compared with that of the average abdominal operation. Patients have far less trouble from nausea, vomiting, or distention. Drainage may in most cases be removed in three or four days when the serum has ceased to come away and no important suppuration has

taken place. In a few cases free suppuration will take place in the cavity from which the kidney was removed, and drainage must be allowed to remain until this has quieted down. In well-sutured wounds hernia seems to be a rare complication, and its occurrence is more often due to muscular paralysis due to injury of the last thoracic and first dorsal nerve than to actual weakness of the scar.

NEPHROTOMY.—Until within comparatively recent times nephrotomy was the operation of election for renal calculi. Before the days of the Roentgen ray, when the presence of stone was guessed at rather than known, it was more justifiable than it is today. At the present time its use should be confined to those cases in which the stones cannot be removed by pyelotomy, the operation next to be discussed. It will thus be indicated for large-branched calculi which could by no possibility be withdrawn through the pelvis and for stones lying in a more or less shut-off calyx the communication of which with the renal pelvis is too small to permit the expulsion of the stone. Nephrotomy may be of two types: It may be partial, involving incision only of the calyx containing the stone, or it may be total, involving the practical splitting of the kidney from pole to pole.

Partial Nephrotomy.—Partial nephrotomy is a simple and quite safe operation, as a rule, involving the division only of a much-thinned portion of the cortex overlying the dilated calyx. In many cases no kidney tissue has to be incised, only a sort of fibrous shell the division of which admits directly into the cavity of the calyx. It is often possible to decide beforehand that such an operation may be necessary. This will depend upon the accurate demonstration of the fact that the stone does not lie in the renal pelvis, and that it does lie in a more or less shut-off calyx, generally the lower, but also frequently the upper one. When this is suspected by the appearance in the roentgenogram or injected radiogram the point may be settled after the kidney has been exposed by the finding of a cystic portion of the kidney corresponding to the expected position of the stone. Under these circumstances, and if only one stone or one collection of stones has been shown to exist, the kidney at this point may be promptly incised without the necessity of opening the pelvis and exploring the rest of the kidney.

Extensive or Total Nephrotomy.—Nephrotomy, except in the partial cases just described, is always an objectionable operation. It involves the division of more or less sound kidney tissue, involves some or considerable loss of blood, and, most objectionable of all, requires suture of the kidney which can rarely if ever be accomplished except by methods which clearly involve further damage to kidney tissue. Moreover, it always exposes to the danger of secondary hemorrhage, a danger the extent of which can never be estimated, and which, when it occurs, is always serious and occasionally fatal. I know of no method by which this occasional accident can with certainty be avoided, and it is therefore an objection to which this operation is always open

and which makes its avoidance imperative when any other operation will take its place. When, as above suggested, the size and shape of the calculus is such that it cannot be attacked by any other route, then, and then only, nephrotomy must be undertaken.

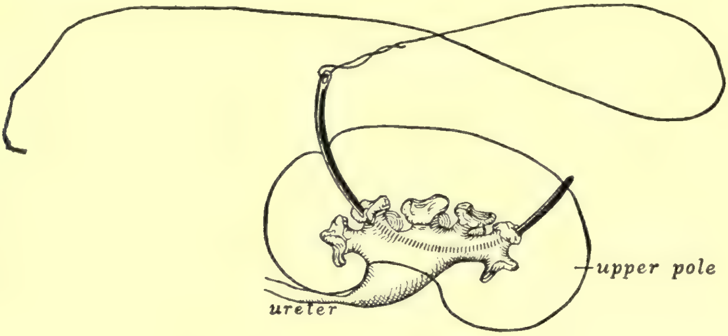

FIG. 236.—(Redrawn after Broedel.)

The Operation.—The kidney should be exposed through the incision above described. It should be thoroughly freed from its fat capsule exactly as if nephrectomy were to be done. A rubber-covered clamp, the pressure upon the jaws of which can be accurately regulated by a set-screw, should then be placed upon the pedicle. Such a clamp is, I believe, entirely superior to the inconstant, uneven pressure of the fingers of the operator or of an assistant. Some blood will inevitably

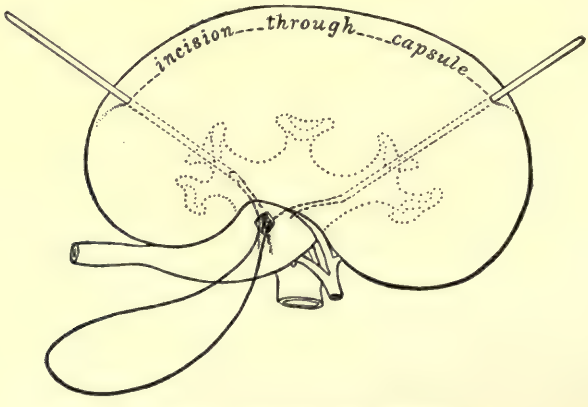

FIG. 237.—(Redrawn after Broedel.)

be lost, and it is only proper that this should be reduced to a minimum. This the clamp will do better than anything else. The clamp having been adjusted at a degree of pressure judged to control the circulation in the kidney, this being estimated by the fact that the kidney does not

tend to fill with blood, the kidney should be freely incised at a point just behind and parallel to the convex border. This has been shown by Broedel to be the line along which the vessels anastomose and few larger vessels will be divided. The kidney should be opened by incision with a knife or by cutting with a wire as described by Cullen and Derge.[5] This latter method is really one of tearing, and is said, and I

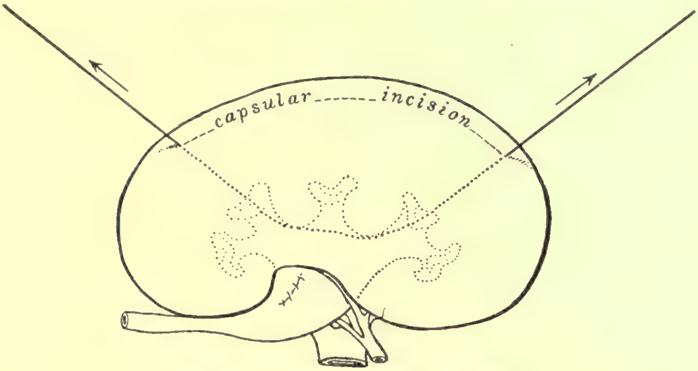

FIG. 238.—(Redrawn after Broedel.)

believe, does give rise to less bleeding (Figs. 236, 237 and 238). The wire is passed either with a curved or with a straight, blunt, flat liver needle through the portion of the kidney to be incised and the wire pulled through. The capsule of the kidney is then divided between the points of exit of the wire and the wire is then pulled back and forth through the wound until the tissue is cut through (Figs. 239 and 240).

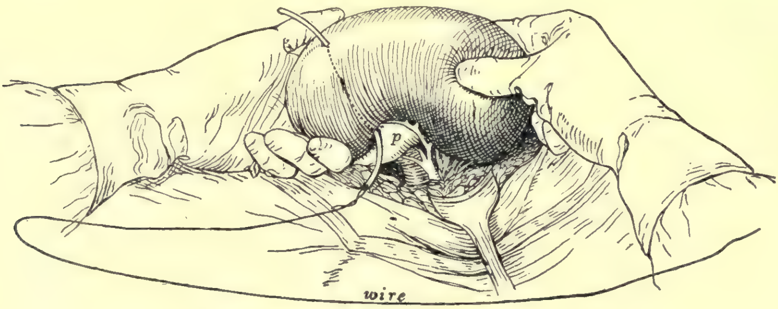

FIG. 239.—(Redrawn after Broedel.)

If the kidney is not sufficiently widely opened at the first cut the wire may be reinserted and the remaining tissue be divided. A sufficient opening should be made in the kidney to thoroughly expose the pelvis. The calculus is then removed, scrupulous care being taken to see that no fragments remain behind. It may even be wise to wash out the kidney with a stream of water to remove debris.

The most difficult part of the operation still remains, that of restoring the kidney so as to control the bleeding and not destroy the organ. From Kelly's clinic has come the suggestion of relaxing the clamp enough to allow slight bleeding and show the position of the larger vessels. It is advised that these be picked up separately with small forceps and tied. This highly desirable method has not been easy of application in my hands, and it has generally been possible to tie only a few of the larger ones. Two methods of suture have been most commonly used:

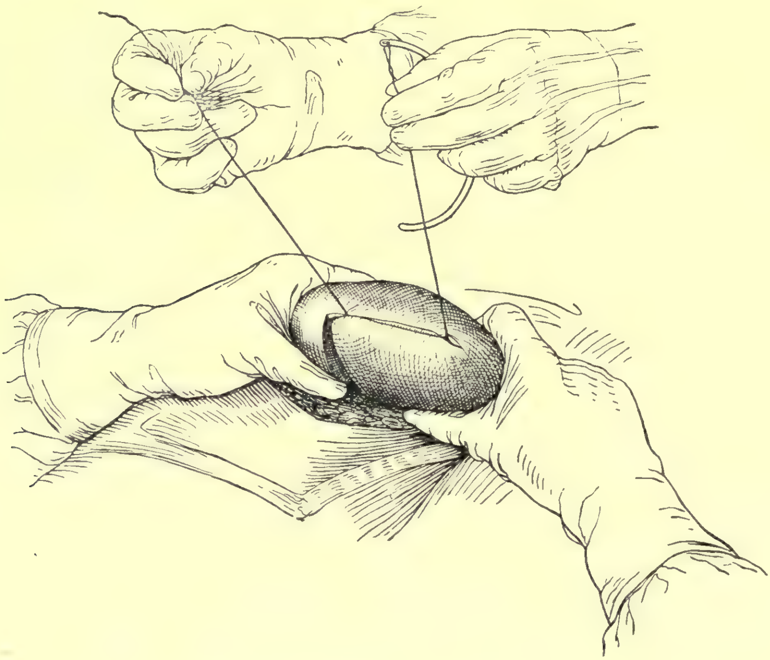

Fig. 240.—(Redrawn after Broedel.)

1. Mattress sutures, generally three in number, one at either pole and one in the central portion of the kidney passed through the entire thickness of the kidney at about the level of the base of the pyramid (Fig. 241).
2. The other, deep sutures simply and not the mattress type, varying in number from three to five or six passed through the kidney from side to side at about the same level as above noted and tied over the convex surface of the kidney.

The use of mattress sutures I believe to be wholly objectionable, since though efficient in controlling bleeding they have in several cases which I have seen so excessively compromised the circulation of the kidney as to result in necrosis requiring nephrectomy. The use of

deep sutures I have found sufficient, and though I believe considerable tissue damage results, it appears to be unavoidable. These deep sutures should be tied, taking the most scrupulous care to see that the amount of tension is not sufficient to cut through the friable kidney tissue before the clamp is loosened. This having been done a moderate amount of oozing between the sutures will generally occur. This is a favorable rather than an unfavorable sign, showing that too much pressure has not been exerted by the deep sutures. This ooze can generally be stopped by a row of superficial interrupted sutures approximating only the edge of the kidney wound with the capsule. It is to be remembered that the bleeding after incision of the kidney, though very free and abundant, is of a type controlled by a very moderate amount of pressure, and that it is not necessary to violently compress the kidney in order to stop it. It is, on the whole, surprising what a moderate amount of pressure will do in the way of controlling what appears to be a very profuse bleeding. The overlying wound should be closed in

FIG. 241.—(Redrawn after Broedel.)

layers as described above in the operation of nephrectomy. Drainage should always be provided as a considerable serous ooze is inevitable. Blood clot will certainly accumulate, and if drainage is not provided a most satisfactory opportunity for infection will occur. Moreover, as these operations are occasionally followed by sharp bleeding it is a comfort to have an opening down to the kidney so that bleeding, if it occurs, will give prompt notice of its presence.

Accidents following Nephrotomy.—Hemorrhage.—The accidents characteristic of the days following nephrotomy, though not common, are likely to be serious. Of these secondary hemorrhage is an ever-present danger, and is, I believe, more common than anything in the literature would lead us to suppose. I judge this from the number of cases which have come to my knowledge in the hands of my surgical brethren, but which, like the few cases which have occurred in my own practice, have nowhere appeared in the literature. The accident does not seem to depend upon any particular type of lesion in the kidney or

upon any particular method of suture of the kidney. It is probably more likely to occur in cases of large stone with considerable ulceration of the pelvis, but the probability of its occurrence can in no way be predicted. It is seen in two forms:

1. The sudden severe single hemorrhage occurring at any time from the day following operation until ten days later. In the worst cases it comes without warning, is massive and fatal. In the milder cases it starts equally without warning and is stopped by pressure over the kidney or by a packing of the wound, neither of which procedures would be sufficient to control a hemorrhage which was at all violent. In many of these cases there is a strong suggestion that the bleeding would have stopped at about the same time if it had been left alone. The sudden severe hemorrhage can only be controlled by prompt opening of the wound and direct pressure upon the kidney. This can only be done when a competent surgeon is on the spot, and must therefore, as a rule, be carried out by someone other than the operator. Even under the best of conditions with a competent surgeon in the hospital at the time the bleeding begins it may be a fatal accident.

2. The other type of bleeding is far less massive and is often a continuation of the bleeding which occurs at the time of operation. In these cases a moderate steady seepage of blood goes on for several days, some of it passing down the ureter to the bladder, part of it appearing in the wound. This if it continues will in time prove a serious business, and it may involve a very nice question of judgment to decide at what point to interfere. An amount of blood which on the day following operation may be regarded as negligible will, if it continues day after day, demand an interference. While no general rule can be laid down for guidance it is safe to say that when it appears that the loss of blood is beginning to tell, as shown by a slowly rising pulse and falling index of hemoglobin, delay becomes hourly more hazardous and the risk of interference is probably less than that of non-interference. On the whole I think we are more likely to postpone operation too long than to undertake it too early, and for this condition I am inclined to think well of the advice—When in doubt operate.

Necrosis of the Kidney.—This is also a rare but serious complication of nephrotomy. It may arise apparently either from too great compromise of the blood supply by the sutures or from infection running wild through the kidney, having been conveyed from the previously infected renal pelvis. The distinction so far as concerns the patient between these two conditions is not important, as both of them demand nephrectomy. On the other hand, the necrosis due to infection is generally characterized by high fever, not infrequently by chills, rapid pulse, and the further evidences of severe constitutional disturbance. In the more nearly aseptic necrosis the constitutional disturbance is often marked but the temperature is less elevated, the pulse often rising out of proportion to the degree of fever. When either of these conditions arises following nephrotomy for calculus the wound should be reopened

and the kidney removed. Operation if not too long delayed is generally brilliantly successful, the kidney being found extensively destroyed either with multiple abscess or with aseptic necrosis. These secondary nephrectomies are often difficult owing to the shortness of the pedicle, and as the amount of time at the disposal of the surgeon is always short it is in this condition more than in any other that the leaving of clamps on the renal pedicle rather than the application of ligatures is justifiable. The surgeon should attempt to live up as well as possible to the surgical maxim—Go in, do your work, and get out as fast as possible.

PYELOTOMY.—Pyelotomy is the operation of election for all stones in the kidney or in the renal pelvis which can be removed through an opening in the renal pelvis. The advantages of this operation over nephrotomy are obvious. No damage is done to any important structure and no large vessels are likely to be divided. It therefore follows that the function of the kidney is in no way impaired and the objectionable features of nephrotomy are avoided. It was widely held, chiefly by German observers, that the operation of pyelotomy was likely to be followed by urinary fistulæ. Why the earlier operations by this method were in fact followed by urinary fistula is not clear, for of late years this complication has not been a troublesome one except in those cases with constriction of the ureter below the pelvis. Obviously under these conditions fistula will result, but in practice such an obstruction is nearly always due to stone in the ureter which has been overlooked, a contingency which can always be avoided if the possibility be remembered. It is possible to cause fistula by prolonged drainage of the renal pelvis with the production of a stiff-walled sinus which does not readily close. This, however, will only occur in cases in which drainage has been allowed to remain an entirely unnecessary length of time.

From the indications above stated it will appear that pyelotomy is today applicable to the great majority of cases of renal calculus. That it is suitable for a far larger proportion of cases than was true before the advent of the Roentgen ray is due to the fact that stones are discovered at a far earlier period in their existence and are therefore more likely to be amenable to management by this method. The proportion of cases in which the diagnosis of renal calculus can be made while the stone is still small is today very large as compared with the situation in the earliest days of renal surgery.

The Operation.—The kidney should be exposed through the same incision as that applicable to nephrectomy or nephrotomy. It is important to mobilize the kidney to the fullest extent, and in the majority of cases this is possible, since the amount of perinephritis accompanying the smaller stones is not likely to be great. In most cases it is possible by carefully freeing the kidney to deliver it partly or wholly from the wound, but in a small number of cases such delivery is impossible on account of various conditions, partly anatomical and

largely inflammatory, which produce relative shortness of the pedicle. One of the most troublesome features of this operation is the difficulty of holding the kidney in such a way that the hand, whether of the surgeon or assistant, which maintains the kidney in place, is not in the way of the operator. For this purpose we have found a rubber-covered forceps devised for the purpose of grasping the uterus to be particularly valuable and have been able to apply it and to handle the kidney by this means without doing harm. Various methods of supporting the kidney by slings of gauze have been devised and practised, but we have found none of them efficient except such as seem likely to bring undue tension upon the renal vessels. In practice, unless a forceps as above suggested can be utilized, we have come to depend upon the hand of an assistant holding the kidney over which is laid a single layer of gauze. This prevents slipping and is free from danger. When a satisfactory exposure of the kidney has been obtained the renal pelvis should be carefully palpated to ascertain the position of the stone. In about half the cases, particularly those in which the stone is small, it is impossible to decide by this means whether or not the stone lies in the pelvis. With stones of fair size palpation is generally satisfactory. The surgeon should, however, have an accurate knowledge of the position generally occupied by the stone before beginning the operation. Thus some stones are of such shape that they must of necessity lie in the pelvis, while others readily retreat into a calyx, and may in this way be overlooked unless such a possibility is appreciated beforehand. Still other stones can be demonstrated before operation to lie in a calyx, and under these conditions it is obviously futile to waste time in exploring the pelvis. When it is known beforehand that a stone occupies or may retreat into a calyx, it is important to know which calyx it occupies. This can be ascertained with certainty by means of the injected radiograph and generally may be satisfactorily guessed at by the relation of the stone to a radiographic catheter passed to the upper limits of the pelvis.

These preliminaries having been settled the position of the renal pelvis should be identified. As a rule it lies in its normal position on the posterior surface of the pedicle behind the renal vessels. If it is dilated or much thickened its position is readily appreciated, but if it is of normal size, and particularly if it is of the intramural type, very little may project beyond the border of the kidney substance, and some difficulty may be experienced in recognizing its exact position and relations. When such a condition exists it is best to identify the ureter, which is always readily done at a point just below the lower pole of the kidney. This can be traced backward and will make the position of the pelvis obvious. In a small number of cases the pelvis will be found more accessible on the front of the pedicle. I have been unable to decide under exactly what conditions this occurs, but have never seen it except when the pelvis was occupied by a stone of considerable size or when considerable dilatation was present. When it occurs,

this peculiarity will be recognized by the fact that the pelvis bulges forward to the front of the pedicle generally below the vessels, but occasionally between them, a fact which, if not recognized, may lead to trouble. On one occasion I saw a surgeon incise the renal pelvis on the front between two large branches of the vein, one of which was subsequently torn in the attempt to extract the calculus. It is certainly important to recognize such a possibility and never to open the pelvis except clearly below the point of crossing of the vessels. Where the renal pelvis is more accessible on the front, no hesitation need arise about opening it on this surface, as in this way better access will be given to the stone (Fig. 242).

The incision in the renal pelvis, generally upon the posterior surface, should be made vertical to the kidney substance at that point and as nearly as possible midway between the extremes of the hilus. If the stone is large and the incision must be prolonged it should be prolonged downward in the long axis of the ureter, and may, if necessary, be carried down to the ureteropelvic junction.

If the stone lies in the renal pelvis it can, as a rule, be easily freed with the tip of a blunt instrument and then extracted with forceps. This having been done the kidney should be carefully explored with curved forceps for other calculi, though, as a rule, the number and position of calculi can be decided before operation and no unexpected stones should be found. When the stone lies in a calyx a suitable pair of curved forceps should be passed directly into this calyx through the opening of the pelvis and the stone removed. It is sometimes a matter of considerable difficulty to find the opening into a calyx from the pelvis. This will be facilitated by taking the kidney in the left hand so that the two hands work in unison. Occasionally, in difficult cases, it may be necessary to insert the finger into the renal pelvis. This can, as a rule, be accomplished without doing violence to the tissues, and though it will not always enter into the cavity of the calyx, it is often possible to map out its positions and render a satisfactory exploration with forceps possible. There are a few cases in which a stone lying in a calyx has grown to such a size that it cannot be withdrawn through the opening of the calyx. Under these circumstances the opening may be enlarged and the stone extracted, or a short incision made through the cortex of the kidney and the stone removed in this way. On the whole the latter method seems preferable, as it is impossible to control bleeding, which may be started within the kidney by the division or tearing open of a calyx, while what bleeding comes from the small incision in the cortex can, as a rule, be satisfactorily controlled by sutures. When, however, the amount of kidney tissue overlying the stone is considerable, and the amount of tearing of the orifices of the calyx need not be great, this latter method may be preferred.

Before concluding the exploration of the kidney, each calyx should be separately searched for calculi whose presence has not been previously appreciated. When multiple calculi have appeared in the plates

taken before operation at least an equal number of stones should be removed—quite commonly the "stone count" will exceed expectations.

Before proceeding to the closure of the wound in the pelvis it is essential to demonstrate the freedom of the ureter from kidney to

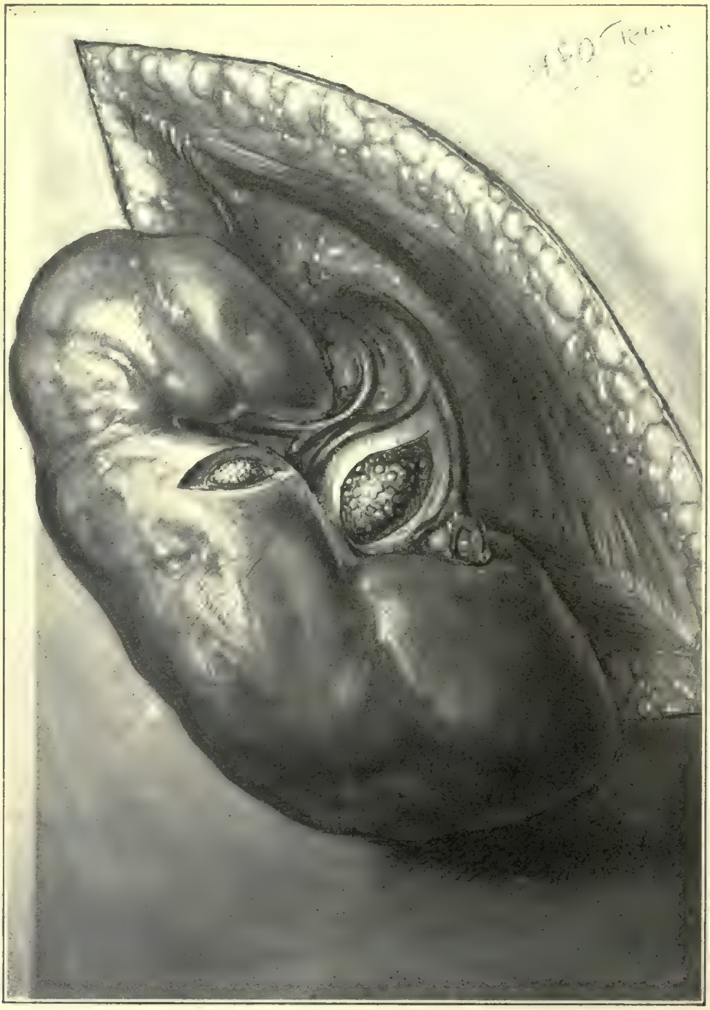

FIG. 242.—**Right kidney laid over toward spine, exposing front of pelvis; large stone removed; small stone felt in anterior lip of hilus; stone removed through small incision in same.**

bladder from obstruction. For this purpose a bougie sufficient to fill the ureter should be passed from the pelvis downward until no doubt exists that it projects into the bladder. Failure to observe this precaution may lead to the overlooking of a stone which has slipped into

the ureter, or which, lying in the ureter, has been previously overlooked, and in either case a urinary fistula, possibly permanent, will result.

The wound in the pelvis should now be carefully closed by suture. For this purpose unchromicized catgut is appropriate, and there seems to be no objection to passing the sutures through the entire thickness of the pelvic tissue. It was formerly taught that it was undesirable to introduce a foreign body of this kind into the urinary passages at any point, but this fear arose apparently from the liability to incrustation with urinary salts. This will only occur in the presence of an alkaline urine, and even then, if the material used does not maintain its integrity for more than a few days, no trouble need be anticipated. We believe that suture of the renal pelvis is entirely preferable to the practice, not uncommon a few years ago, of leaving it open. While it is quite true that these wounds heal readily and accurately without suture, they certainly heal more readily and more accurately with sutures. In the majority of cases when a good exposure has been possible the suture may be made so tight that little if any leakage occurs. When the tissue of the pelvis has been found friable and good approximation is difficult the line of sutures may be covered with a sort of flap from peri-pelvic fat tissue, as suggested by Mayo. This is only necessary in the more unsatisfactory cases. The closure of the wound in the abdominal wall should follow the same principles as those appropriate to other kidney operations. Drainage is always indicated, and a small piece of rubber tissue down to the region of the renal pelvis is quite sufficient. We have seen no advantage in the drainage of the pelvis by means of a tube. The unobstructed ureter is quite as efficient and does not expose to the possible danger of fistula.

After-treatment.—After pyelotomy, as after nephrotomy, the condition of the urine should be carefully observed. Some blood, though of small amount, should appear in the urine during the first twenty-four hours. Should there be an entire absence of blood this may be taken as evidence that the urine from the affected kidney is not reaching the bladder and should raise a suspicion of ureteral obstruction. If the ureter has been explored as above suggested this obstruction must be due to blood clots or fragments of tissue, and may be expected to disappear of its own accord. If, however, the renal pelvis continues to discharge its contents through the wound after a week or ten days it is quite justifiable to catheterize the ureter on that side, wash out the renal pelvis, and be sure of the patency of the ureter. In a few cases constant ureteral drainage with an in-lying catheter is desirable. This is, however, rarely necessary after pyelotomy.

The drainage should be left in the wound longer than is necessary after nephrectomy or uncomplicated nephrotomy. This longer drainage is of importance because leakage occasionally takes place after the sutures have absorbed at about the end of a week. If the drainage has been removed at the end of forty-eight hours the wound may have largely closed, and such a leak would give rise to a collection of urine

in the perirenal tissue, which will have to be drained. This accident can always be avoided by leaving the drainage in place for six or seven days, which seems to us wholly unobjectionable.

Operations for Bilateral Stone.—When stones exist in both kidneys two questions not raised by unilateral calculi confront the surgeon. Shall both kidneys be operated upon at the same sitting, and if so which kidney shall be attacked first? If but one kidney is to be operated upon, which of the two shall be selected? In answering these questions it may be observed that the theory is clearer than the practice. In theory it is obviously desirable that both kidneys should be operated upon at the same sitting. In practice this can only be done when the operation upon one kidney can be carried out in a comparatively short time, leaving the patient in a condition so good that the operation upon the second kidney may be attempted without improper risk. As a matter of fact the question will be answered at the time of operation. If all has gone well with the first kidney the second one may be dealt with. If the first operation has proved unexpectedly tedious the removal of the remaining stones should be postponed. We have made it a working rule not to operate upon the second kidney unless the operation upon the first could be completed in thirty to forty minutes. Whether or not this can be done will depend upon the corpulence of the patient, the amount of perinephritic adhesions, and the skill of the operator. The remaining questions practically resolve themselves into one, since the kidney which should be operated upon if only one is to be dealt with is obviously the same as that which should form the first stage of a bilateral operation at the one sitting. Upon this point the argument made by Watson seems to us sound. It has been common advice to operate upon the worst kidney first. Watson, on the contrary, maintains that the better of the two kidneys should be operated upon first for the following reasons: The kidney not operated upon is liable to be obstructed at any moment by the change of position of its calculi. Should this occur in the better of the two kidneys the patient will be obliged to get along with only his worst side at work. If the better kidney has been operated upon the blocking of the remaining kidney will leave him with the better side in good working order. While this may seem a wholly theoretical objection, precisely the contingency suggested by Watson occurred in our practice with the exact results which he had predicted. The most destroyed of two calculi-containing kidneys had been operated upon. Ten days following operation the remaining better kidney became completely obstructed and total anuria resulted. Prompt operation for the removal of the obstruction restored the function on both sides.

Some difficulty may be experienced in deciding which is the better of two kidneys, since, as pointed out above, we have no very satisfactory method of measuring the function of these kidneys. In

general, however, the larger calculi usually exist in the worst kidney. The general characteristics of the urine as concerns specific gravity, total urea, etc., will give a fairly accurate indication, and upon these two facts a decision must be made. If it has been thought best to operate upon only one kidney, or if in spite of a desire to operate upon both sides it has been possible to remove the stones from only one, the second operation should not be undertaken until convalescence from the first operation is complete. We have thought it a better practice to postpone the second operation for six weeks to two months, and have thought that our patients do better than when the two operations were separated by an interval of only two or three weeks.

OPERATIVE TREATMENT OF URETERAL CALCULI.

Operative treatment of ureteral calculi may be of two types:

I. Those manipulations which can be carried out with the aid of the cystoscope.

II. Cutting operations.

I. Cystoscopic Operations.—Of late years a considerable number of methods have been described having for their object the displacement of ureteral calculi in such a way as to facilitate their evacuation. These have been described by Lewis, Buerger, Bryan and Braasch. In general they are of three types:

1. Mere displacement of the stone by pressure against it with a ureteral catheter or a bougie may be of value in two ways: It is frequently successful in stones caught in the first portion of the ureter in pushing these stones back into the renal pelvis and relieving the colic for such time as is necessary to allow a satisfactory study of the conditions previous to operation. Stones situated in the lowest portion of the ureter, and particularly those in the intramural portion, are occasionally passed to the bladder following manipulations with the ureteral catheter. Precisely what part the ureter catheter plays in this performance is not easy to say. In some of the cases at least the only effect is apparently to stimulate contractions of the ureter with efficient results. In others it is probable that the stone is twisted in such a way as to present a more favorable axis to pressure of the column of urine behind it, or it may be that a spicule of the stone actually caught in the mucous membrane is released.

2. Various writers have advocated the passage of a bougie catheter by the stone when such a manipulation is possible, and the injection into the ureter above the stone of a variety of liquids. Of these sterile oil, glycerin and various anesthetic solutions have been advised. It is not easy to believe that these have any important result, as the lubricating effect upon the ureter is probably negligible, and there is no reason to suppose that they exert more pressure upon the stone than does a collection of urine. In theory the use of anes-

thetic solutions has merit, as it is entirely conceivable that by relaxing spasm of the ureter at the point where the stone is caught they might assist in its passage. In practice, however, I am frank to say that though I have used them in a considerable variety on many occasions I have never had reason to believe that they have any desirable effect. All of the methods above described have been followed by the passage of calculi in a small proportion of the cases, but I tend to believe that the mechanical irritation produced by the ureter catheter is the most important element in that result.

3. More recently division of the ureteral orifice or dilatation of the lower portion of the ureter has been advised, and instruments for use through the operating cystoscope have been devised by Lewis and Buerger. These are far more pretentious undertakings than those just referred to, and may be expected to have much more positive results. They are chiefly applicable to stones arrested in the intramural portion of the ureter, though various surgeons, including the above mentioned, have been successful in removing calculi from various levels in the pelvic portion of the ureter. For their satisfactory execution they require a high degree of skill in cystoscopic manipulations, and are not within the reach of the casual cystoscopist or the beginner.

Technic of Cystoscopic Operations.—For the manipulations described under headings 1 and 2 above an ordinary catheterizing cystoscope of any type is quite sufficient. There should be on hand ureter catheters of various sizes from No. 4 to Nos. 7 or 8 French, and these should be bougie-tipped as well as flute-tipped. For the purpose of locating the point at which the stone is arrested an ordinary No. 6 catheter may be employed and passed into the ureter until arrested. If it will pass the stone with some urging no other instrument need be used. This, however, will rarely occur, and it is generally desirable to try a rather stiff bougie catheter of medium size next in order. Should this fail to pass the smallest and stiffest bougie catheter should be selected and tried. Those armed with a fine whalebone tip have not been satisfactory in my hands, as they tended to become caught in various folds in the ureter often at a point considerably below the stone. If no instrument can be made to pass the obstruction nothing further can be expected from this method of procedure. If a catheter or bougie has been made to pass through the former some of the above-mentioned solutions may be injected, and for the latter a bougie catheter may be substituted. It has seemed of some benefit to empty the ureter above the stone by means of a catheter, as in this way a different application of the stone to the ureter is likely to result, perhaps with favorable consequences. While the injection of solutions has not been brilliantly successful, if they are sterile, the experiment is without objection, and further trial may yield better results. It is probably wise to try these various measures before resorting to the more uncomfortable and possibly objectionable cystoscopic

operations. An interval of at least three or four days should elapse between attempts unless during this time symptoms are severe or anuria threatens. Under either of these circumstances a radical cutting operation should be substituted. For the cystoscopic operations a cystoscope constructed for the purpose; that is to say, one having a large catheter channel, and suitable instruments, including dilators, scissors, and forceps, are necessary. The only instruments with which I am familiar are those of Lewis and Buerger, and only with the latter have I had actual experience. If the stone is arrested very close to the ureteral orifice a simple snipping of the orifice on its upper surface will probably be sufficient. In a few cases in which

Fig. 243.—Ureteral calculus, removed with operating cystoscope.

the stone partially protrudes it will be possible to grasp it in the forceps and extract it. In the majority of cases, however, the ureteral orifice should be enlarged and the stone then given an opportunity to pass of its own accord (Fig. 243). Should this fail to occur within a few days the ureter should be dilated, first with larger catheters and then with the mechanical dilator. It is theoretically quite possible to dilate a stricture which is preventing a stone from passing, but the actual success of this procedure has not as yet been attested by a number of cases sufficient to enable it to be fairly judged. Our own experience has been limited to a comparatively small number of cases, and we have been successful only in extricating calculi which lay in the intramural portion of the ureter, and even this has occa-

sionally failed. It seems probable, however, that with increased experience, and perhaps slight modification of instruments, it will be possible to avoid more radical operation for calculi arrested in this position. At the present time it may safely be said that this method of removal should always be used and given a thorough trial before more radical operation is undertaken. Some question may arise as to whether the straight cystoscopic tubes of Kelly should be employed in manipulations of this kind in women. Opinion seems to be gaining ground that the smaller instruments which consequently cause less discomfort, and which were formerly used only in the male, are equally satisfactory in the female. Kelly's tubes require very considerable experience to make them of practical value, and as their use is only superior in a very small group of cases, it seems likely that they will be entirely abandoned in favor of the male type of cystoscope.

II. **Cutting Operations.**—The vast majority of ureteral calculi are arrested in the upper third or in the pelvic portion of the ureter. Not less than 90 per cent. lie in one of these two positions and more than 75 per cent. are likely to be found in the latter position. It therefore follows that operations for the removal of stone in the ureter must be planned to reach the stones near the kidney and those in the pelvis.

Operations upon Stone in the Upper Third of the Ureter.—The incision for approach to this portion of the ureter is practically the same as that for reaching the kidney, though it need not be carried so far back, and for those stones farthest from the kidney should go somewhat farther forward. It is not necessary to mobilize the kidney to any great extent, and often not at all, except upon its posterior surface. The peritoneum covering the lumbar muscles should be stripped off and the ureter located at a point several inches below the kidney. It is to be remembered that the ureter does not, strictly speaking, lie behind the peritoneum but rather in, or between, the layers of that membrane, and that it will therefore be pushed forward as the peritoneum is stripped from the muscles. This has been a source of much difficulty to those unfamiliar with the operation, and frequently much time has been lost in searching for a ureter which had been pushed forward and covered by a retractor. If it be remembered that the ureter will be raised with the peritoneum, and that there is no other structure running in this direction in this neighborhood, except the spermatic and ovarian vessels, no great difficulty will be experienced. The ureter having been located, it should be followed upward or rather backward toward the kidney. Stones caught at the uterovesical junction may be readily displaced into the renal pelvis, and if this is considerably dilated the accident may be a troublesome one. Care should therefore be exercised in stripping up the ureter, and when the stone is once felt it should be grasped and not released until it is removed. Even if the stone lies well

down in the upper third it may readily be displaced backward, and on this account no chance should be taken. If the stone is caught at the ureterovesical junction the incision for its removal should be made in the renal pelvis and not in the ureter. This is important, since should the incision be made directly over the stone it may divide the already rather narrow junction of ureter and pelvis and the resulting scar give rise to troublesome stricture. The stone having been removed a bougie should be passed through the ureter to the bladder for the same reasons as those laid down under stone in the renal pelvis. In no other way can the freedom of the ureter from obstruction be known with certainty. If the stone lies in the ureter below the pelvis the incision for its removal should be made an inch or more above the stone, which then should be extracted with forceps. The precaution of making the incision above the stone and not over the stone, as frequently advised, is that stricture may be avoided.

Stones in the Midportion of the Ureter.—Of the comparatively small number of stones which lodge at this point the majority will be found at the point where the ureter crosses the iliac vessels and is caught to their sheath by a fibrous band. It will be remembered that the line of the iliac vessels is, roughly, from a point just below the umbilicus to the middle of Poupart's ligament. The ureter crosses this line almost perpendicular to it at a point midway between the umbilicus and the anterior superior spine. An oblique muscle-splitting incision with its centre over the point of crossing will give good access to this portion of the ureter. The crossing of the iliac vessels and the ureter is always at the bifurcation of the vessels, and if the exploring finger be passed to the bifurcation the ureter will be found promptly. It should be mobilized somewhat above this point, opened, and the stone milked back or extracted with forceps. The wound in the ureter should be carefully closed and the dilatation of the ureter by the stone will give sufficient tissue to enable a thoroughly satisfactory coaptation to be obtained. I believe that there is no objection to introducing fine unchromicized catgut sutures into the lumen of the ureter, and am satisfied that the suture is in this way made more secure.

Stone in the Lower Third of the Ureter.—Of the stones which lodge in the lower third of the ureter, which, it will be remembered, constitute a large majority of all ureteral calculi, the largest number will be lodged in the lower two and a half inches of the ureter. Of these some will lodge just without the bladder wall, some at the point where the ureter crosses the uterine artery, and others in the intramural portion of the ureter. For stones in the lower third outside of the bladder wall an exposure which gives access to the ureter without opening the bladder is necessary, while the stones in the intramural portion should be removed by cystotomy if they cannot be removed by a cystoscopic operation as above discussed.

I. OPERATION FOR STONE IN THE PELVIC URETER OUTSIDE THE BLADDER WALL.

For this purpose two types of incision are not uncommonly used: (1) A median vertical incision as for cystotomy, the bladder being pushed aside and not opened, and the other (2) an incision parallel to Poupart's ligament, starting in the median line, following the oblique fibers of the abdominal muscles and turning upward at its outer end, as described by Gibson.

1. **Median Incision.**—This incision should have its lower end slightly below the upper margin of the pubis and extend upward in the median line toward the umbilicus. The exact length will depend upon the thickness of the subcutaneous fat and should be made sufficiently long to give ample access to the pelvis. When the peritoneum is reached it is stripped back off the bladder and from the front of the abdominal wall, giving a free exposure of the lateral surface of the bladder on the side involved. The patient should then be placed in a Trendelenburg position so as to remove the pressure of the intestines. The bladder itself should be picked up in catch forceps and pulled to one side, so as to facilitate the dissection down toward its base. The chief difficulty in this operation lies in identifying the position of the ureter, and it is often remarkable at what a depth it can secrete itself. It will be recognized by its structure and position. The dissection must be made with the fingers and should be carefully done to avoid tearing the perivesical veins. While slight oozing may be disregarded, any vessels of sufficient size to keep the field covered with blood should be picked up and tied. A reasonably dry field is essential to a satisfactory operation. When the position of the ureter has been identified it should be freed somewhat from the surrounding tissue and a loop of tape or some similar material placed around it. In this way it is steadied, and further manipulation much facilitated. Where there is considerable periureteral inflammation it may not be possible to identify the position of the stone by palpation. The ureter should be opened at a point above where the stone is known to lie and a metallic probe passed down, when the stone will readily be felt. As elsewhere in the ureter, incisions upon the stone are to be avoided if possible. In a few cases the stone will be so tightly wedged in the ureter that it cannot be mobilized even with forceps. Under these circumstances an incision directly over it is unavoidable. The wound in the ureter should be carefully closed with interrupted fine catgut sutures. This operation is satisfactory for stones in the immediate neighborhood of the bladder wall in patients with a wide pelvis and not too much fat. For fat patients and for men with a narrow pelvis and strong muscles it is somewhat less satisfactory than the oblique incision of Gibson, and it is not applicable to stones in the lower third of the ureter but away from the bladder wall.

2. **Gibson's Incision.**—This incision should start somewhat across the middle line from the side of the stone about half an inch above

and parallel to Poupart's ligament. It should be carried outward to the junction of the outer and middle third of this structure and then turn upward toward the anterior superior spine. It should be deepened to divide the anterior sheath of the rectus muscle. It then goes between the oblique fibers of the abdominal muscles until the point at which it turns upward is reached, where it will be necessary to divide a few fibers of the internal oblique at the outer end of the incision. The deep epigastric vessels cross this incision at right angles and should be divided between two ligatures. The peritoneum is then readily stripped from the pelvis, and with the patient in the Trendelenburg position a first-class exposure of the whole pelvic portion of the ureter can be obtained. It is generally best to identify the ureter just below the crossing of the iliac vessels and to throw a loop of tape around it at this point before following it downward into the pelvis to the point at which the stone is known to have lodged. This portion of the ureter will be found generally to be surrounded by considerable periureteral inflammatory tissue, and this may often serve as a guide to the position of the stone. The most common error is in not recognizing the depth at which the ureter lies in the pelvis. In the female the uterine artery crosses the ureter close to its junction with the bladder and must be recognized and pushed aside. In our experience it has rarely been necessary to tie this vessel. As in the operation just discussed, the ureter should be opened an inch or more above the point at which the stone is supposed to lie and search then carried out with a metallic instrument. A variety of narrow-bladed forceps and scoops should be at hand, as it is not infrequently difficult to disengage these stones from their bed. In a few cases they cannot be dislodged without breaking them to pieces, and they must then be extracted through an incision directly upon them.

The stone having been removed, the patency of the ureter should be satisfactorily demonstrated by the passage of full-sized bougies to the bladder, and it is also wise to explore the ureter upward unless it is obviously dilated. The wound in the ureter should be closed with sutures above described.

In both this and the foregoing operation drainage should be left down to the site of suture not only to avoid the results of possible leakage but to drain the serum which inevitably accumulates after these operations. The wound may be closed snugly about this drain in layers and the incision as described by Gibson gives a thoroughly strong satisfactory scar. It is the incision of election for stones not in the lowest portion of the ureter in fat patients and in muscular men with narrow pelves.

Vaginal Ureterotomy.—This operation has a small field of usefulness. It is only satisfactory when the stone can be readily felt by palpation and in those cases in which it does not tend to slip backward during manipulation. Furthermore, it can only be carried out in parous women when ample room for manipulation is given. With the patient in the

lithotomy position the perineum is retracted, the cervix pulled down, and the vaginal wall incised on one side of the cervix somewhat in front of the midline of the cervix. Through this incision in the vaginal wall the finger is inserted and the ureter freed by blunt dissection. As soon as possible a loop of tape should be thrown around it to prevent the stone from slipping backward. Should this have occurred it is sometimes possible to reach it after the ureter is open by means of a long narrow pair of forceps. The suture of the ureter after extraction of the stone is particularly difficult, and though it should be attempted is often unsatisfactory.

II. OPERATION FOR STONE IN THE INTRAMURAL PORTION OF PELVIS.

Stones situated in the bladder wall can best be reached from the cavity of the bladder. The bladder should therefore be opened by an ordinary suprapubic cystotomy and the stone located in the bladder wall by palpation. This is ordinarily not difficult, but may occasionally be facilitated by the passing of a fine metallic probe bent to a right angle into the ureteral orifice in order to ascertain the distance of the stone from the opening. The bladder wall above the stone should then be firmly grasped with tenaculum forceps in such a way as to prevent the stone from slipping backward. This also has the effect of pulling the bladder wall up into the field and giving better access to the ureter. The orifice and the intramural portion of the ureter should be freely divided until the stone can be picked out with forceps. Often the little circular artery which passes around the ureter at this point will be divided, giving rise to smart bleeding which will obscure the field. It should be picked up with forceps and later secured with suture. We believe it to be unobjectionable to divide the ureter to any extent within the bladder wall, and have never known subsequent difficulty to follow. The stone having been extracted the ureter may be repaired by suture if the incision has been more than of the orifice. Under the latter conditions suture is not necessary except to control bleeding. Hemostasis should, however, be efficiently obtained, as a moderate amount of oozing will seriously interfere with bladder drainage. When all bleeding has been stopped the wound in the bladder should be completely closed with two layers of sutures, the first going through all the layers of the bladder and the second turning in the bladder wall over the first layer. The layers of the abdominal wall should then be sutured, leaving a small drain down to the bladder wall and coming out about the centre of the wound. It is advisable to keep the drainage away from the lower end of the incision as the possibility of infection of the prevesicle space seems in that way more likely to be avoided. The bladder should be drained with an in-lying catheter for the first twenty-four hours or until the urine is substantially free from blood. Early removal of the catheter is desirable since the suture of the bladder

wound is stronger during the first few days than at any subsequent period up to two weeks, and if the bladder function is taken up at this time leakage is not likely to occur. Retention of urine must of course be avoided, and should it occur, regular catheterization or constant drainage must be instituted. Since, as a rule, these bladders are comparatively free from infection, suprapubic drainage has seemed to us quite unnecessary. In cases with marked infection, drainage with a small suprapubic tube may be desirable.

AFTER-TREATMENT OF OPERATIONS FOR STONE IN THE URETER.

The management of drainage in these cases is not essentially different from that applicable to stone in the kidney. In the pelvic operations it has been our custom to leave the drainage rather longer than in the renal or upper ureter cases, since leakage occasionally takes place as late as the eighth or tenth day, and should drainage have been removed early, a troublesome accumulation may occur much prolonging convalescence. We have seen a few cases in which this accident gave rise to a very chronic abscess which was trying to the patient and required rather variegated explanations on the part of the surgeon.

Ureteral Fistulæ.—Urinary fistula is a far more common complication of operation for stone in the ureter than of operation for stone in the kidney or renal pelvis. Its occurrence is of course due to the presence of obstruction which is most commonly one of three types: (1) A stone which has been overlooked or which may have subsequently come down from the kidney. (2) Stricture of the ureter either produced by ulceration or by constriction due to sutures. (3) Gross disproportion between the dilated ureter above and the normal ureter below.

1. The leaving of a stone in the ureter is today a rare accident since modern methods of diagnosis enable the surgeon to decide beforehand the position and probable number of the stones.

2. Stricture of the ureter is comparatively common. Every effort should be made at the time of operation to avoid its occurrence. If there appears to be distinct narrowing below the point of lodgment of the stone this stricture may be divided and an in-lying ureteral catheter such as that devised by Albarran placed in position. Our experience has not been happy with the attempt to do a plastic operation upon such strictures. Sutures placed for this purpose have been more likely to produce than to relieve obstruction and it has seemed as if the in-lying catheter was the better method.

3. A most serious though not common source of difficulty occurs in those patients in whom a larger stone has come down and lodged in the lower portion of the ureter, causing extreme dilatation. When this stone has been present for some time the overdilatation of the ureter is such that return to anything approximating normal will not take place. Under these circumstances the column of urine lying in the

ureter above the point at which the stone was arrested is so much greater than the capacity of the ureter below that point and the contractile power above is so much diminished that a potential stricture exists. This situation can rarely be appreciated with certainty at the time of operation and should it exist the occurence of urinary fistula is extremely probable.

Treatment of Ureteral Fistulæ.—A urinary fistula may be regarded as existing when the leakage from the ureter which not uncommonly follows operation persists more than a week or ten days. Such persistence should arouse grave suspicions that some one of the above-described conditions exists. The first effort to overcome the fistula should be by the passage of a ureteral catheter. In a considerable number of cases this will pass the fistula and drain the ureter above. Should this happy result occur the ureteral catheter should be passed to the kidney, the cystoscope removed, and the catheter fastened in position. The fistula will then cease draining and after a lapse of three or four days the catheter may be withdrawn. If it fails to drain satisfactorily it may still be of benefit for a short time, but should it become blocked and leakage occur it should be removed and either replaced by another or by a different kind of catheter, such as that of Albarran, with a wide-open end. In most cases the catheter will drain satisfactorily for several days and if necessary may be left in place for a week or even ten days, as it does not appear to do important damage by its presence. Should the catheter fail to pass an attempt to remedy the defect in the ureter by this method should not be abandoned. Several attempts made at intervals of four to six or seven days should be made before accepting failure as the alternatives are not attractive. They consist in an attempt to do some plastic operation upon the ureter which is generally a failure, the reimplantation of the ureter into the bladder at some point above the normal opening, and as a last resort, nephrectomy. It is generally best not to attempt the radical cure of ureteral fistula until sufficient time has elapsed to allow healing of all the damage done by the original operation. Probably a period of from six to eight weeks at least is desirable. In spite, however, of delay the ureter about the fistula will be surrounded by dense adhesions, and any operation is certain to be one of considerable difficulty. Plastic operations in a tissue infiltrated with urine are generally a failure. It is, however, occasionally possible to open the ureter some distance above the fistula, to pass a catheter down to the bladder and then push it upward toward the kidney in such a way as to reëstablish the canal. In favorable cases this should be attempted. Should this be impracticable the choice lies between division of the ureter with implantation into the side of the bladder and nephrectomy. Reimplantation should always be done if the ureter is long enough to reach the bladder without tension. When tension is unavoidable, implantation is likely to be a failure. The operation of implantation is not of itself difficult. A point on the bladder wall should be selected which will go

into the ureter readily and allow this to project into the bladder cavity at least half an inch. A small incision is made in the bladder wall, the ureter pushed through the wall, sutured snugly around it, and the ureter attached to the outer surface of the bladder. It has seemed to us wise to leave this free portion of the ureter projecting into the bladder so that it may accommodate itself to the necessary extent without producing tension. Where the fistula has occurred in such portion of the ureter that it cannot be approximated to the bladder without tension, after it has been divided and freed, nephrectomy must be done. The exception to this would be in cases of bilateral calculus in which the preservation of the kidney was essential. Under these circumstances lumbar ureterostomy or nephrostomy might be the choice of evils.

FIG. 244.—Showing condition as shown by roentgenogram on February 1, 1916.[1]

PROBABILITY OF RECURRENCE OF STONE.

Literature is surprisingly guiltless of any attempt to estimate the probability of recurrence of stone after operation. A year ago we succeeded in getting to return to the hospital for reobservation 87 cases in which stone had been removed from the kidney or ureter by operation more than a year and a half previously. Of these 66 were cases of

[1] Figs. 244 to 248 show the rapidity with which stone may form in the kidney.

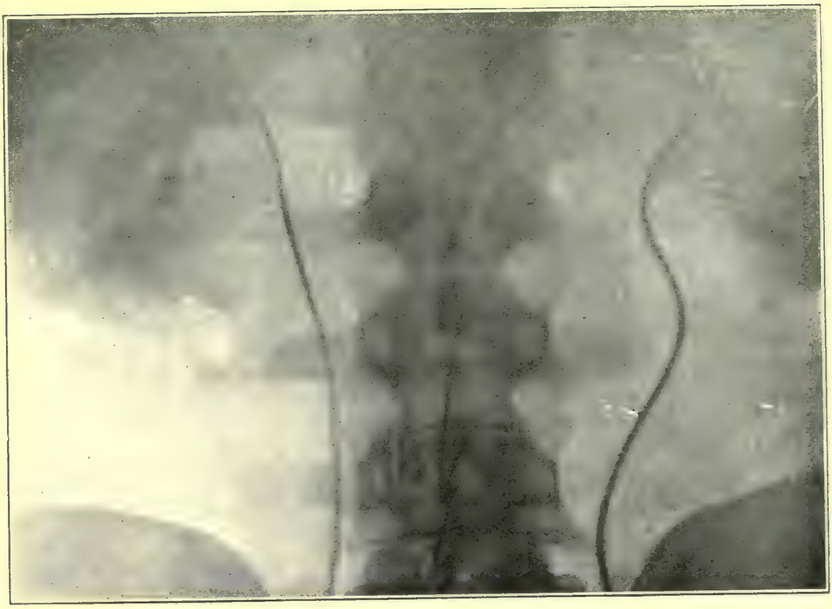

FIG. 245.—Showing the condition thirty-eight days later. Note the marked increase in size of calculi on both sides, particularly on left.

FIG. 246.—Operation of nephrotomy performed on left kidney on March 13, 1916, three days after plate shown in Fig. 245 was taken. Fig. 246 shows condition of both kidneys on April 10, 1916 (one month after operation). Note that stones were either not entirely removed or have recurred on the left side, while stone on the right has increased in size.

FIG. 247.—Stone in right kidney was removed on May 17, 1916, by pyelotomy, showing conditions existing on October 21, 1916. Note that stones in left kidney have increased in size and density. Right kidney at this time apparently free from stone. Chemical analysis of stones removed at both operations showed them to be similar and to consist of calcium phosphate, ammoniomagnesic phosphate and calcium carbonate.

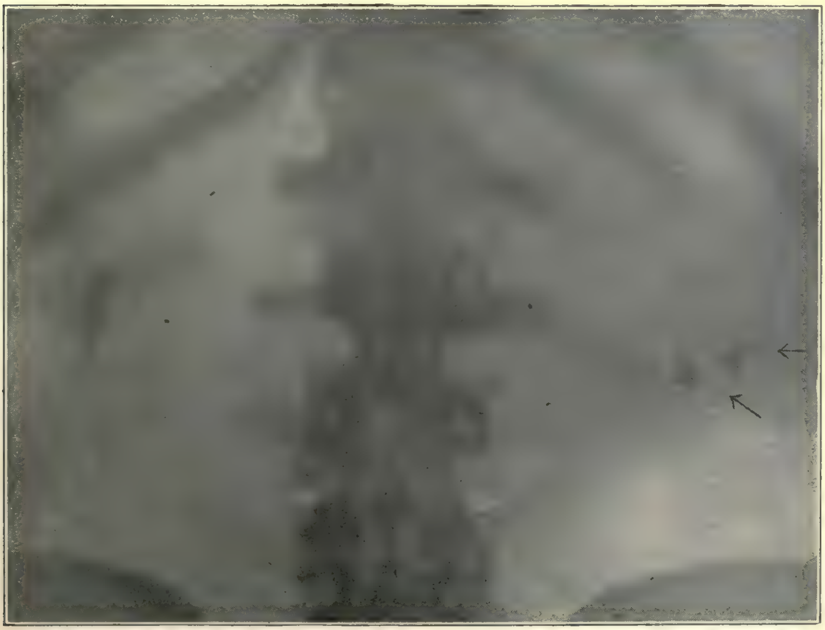

FIG. 248.—Showing conditions December 5, 1916. Note further growth of stones in left kidney and appearance of definite stones in right as shown by arrows.

stone in the kidney and 21 of stone in the ureter. Of the cases of stone in the kidney 34 were entirely well and 32 showed either a persistent infection or recurrent stone. Of the cases of nephrotomy 30 showed 43 per cent. of cure, while of 33 cases of pyelotomy 49 per cent. were well. Of 12 cases of nephrectomy 11 were well and 1 showed stone upon the other side. Of the 21 cases of stone in the ureter 15 were well, 6 had had further trouble. This showing, coupled with our further experience tends to show that caution should be observed in giving a thoroughly good prognosis after operations for stone in the kidney. Recurrence is probably most frequent in those cases where there is considerable renal retention and infection, less frequent in those where the kidney has been but little damaged and is free from infection. Very rapid recurrence had taken place in several patients from whom large bilateral calculi had been removed, so rapid in fact as to raise grave doubts of the propriety of operation (Figs. 244 to 248). Until further statistics admitting of a more accurate opinion have been gathered, it is wise to say to patients who insist upon a positive answer that the probability of recurrence is perhaps as great as one in three. A much more careful study of the late results of these cases is clearly indicated, and I suspect that such a study will temper considerably our enthusiasm for operative treatment, though it is not likely to alter our opinion that the presence of a stone is incompatible with the integrity of a kidney and that it should be removed even though the probability of recurrence may be considerable. If the stone has been of the type occurring in an alkaline urine, it is conceivable that methods looking to the removal of the coccus infection by the use of the Bulgarian bacillus or the Bacillus acidophilus might be of benefit. All this, however, is somewhat beside the point until we are in a position to state with considerably greater accuracy what the percentage of recurrence is, and what relation it bears to the previous existence of infection or the occurrence of infection following operation.

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CHAPTER XVII.

TUMORS OF THE KIDNEY.

By HORACE BINNEY, M.D.

Introductory.—The history of the development of our knowledge of renal neoplasms is singularly complex. As early as the middle of the nineteenth century attempts were made by pathologists to differentiate and classify these tumors but no general agreement as to the nomenclature was reached until 1883, when the work of Grawitz drew the attention of the medical world to a large class of tumors which soon became known as "Grawitz" tumors. Hitherto the majority of writers had accepted the theory that all renal growths were derived from the kidney epithelium, with the exception of teratomata and mixed tumors, which were explained on Cohnheim's theory.

The question of development had received little attention, and in consequence the histological study was not actively pursued until the impetus given to the subject by Grawitz led many investigators into this field. In the words of Albarran and Imbert, "The histological study of tumors of the kidney might have had no history were it not for the disputed question of their development."

The attention of pathological anatomists was focussed by Grawitz's advancement of his theory of origin of certain tumors, previously considered lipomata, from aberrant fragments of the adrenal gland. It was already known that at autopsy such aberrant tissue was occasionally found in the substance of the kidney. These adrenal "rests" Grawitz sought to establish as the origin of certain malignant tumors, to which he gave the name of pseudolipomata, owing to the presence of fat in the cells. Many authors came forward to the attack or defence of his theory, some of his followers being so ardent as to apply his theory to nearly all renal tumors. Grawitz, however, cautioned against this, confining his theory to a definite group.

Following Grawitz's publications other important ones appeared from time to time, representing investigations on all kinds of renal growths, with special reference to pathogenesis and classification. Manasse, in 1895, reviewed the many conflicting theories, and attempted to classify tumors on the basis of origin from epithelium, connective tissue, bloodvessels, or aberrant adrenal germs.

Hildebrand brought out his theory and attempted to substitute the terms endothelioma and perithelioma for adenoma and carcinoma. Sudeck attacked Grawitz's theory and returned to the older theory of the origin from renal epithelium. Birsch-Hirschfeld, in 1894, called attention to the group of embryonic or mixed tumors, which he attributed to inclusions of the Wolffian body in the kidney.

Stoerk[46] made a vigorous attack upon the Grawitz theory, believing the adrenal origin to be unproved.

More recently the controversy has been between the supporters of Stoerk and those of Grawitz. The more important contributions to the subject will be mentioned under the headings for the particular types of tumor.

The statistics on the frequency of kidney tumors in general are of some interest. Kaufman found 87 renal tumors in 1035 autopsies, a much larger proportion than Kelynack, who found but 9 in 4500 autopsies. Of secondary tumors he found 10 renal metastases in 129 cases of carcinoma and the same number in 69 cases of sarcoma of various organs. The predilection for renal tumors to develop in early life is well known. Of 160 malignant tumors Kelynack found 52 per cent. occurring under the age of ten years.

Classification.—From the stand-point of pathological anatomy any attempt at an orderly and comprehensive classification of renal tumors is at present extremely difficult if not impossible. Many writers have labored to this end, but as yet no single system has been generally accepted. As pointed out above, the earlier studies were based purely on the histological structure, resulting in the introduction of many terms (endothelioma, perithelioma, adenocystoma, tubular carcinoma, alveolar sarcoma, carcinoma, and angiosarcoma, etc.). While the concentration of investigators upon the question of origin has brought a greater semblance of order out of the vast chaos of nomenclature, the more notable instances being in the work of Grawitz on adrenal rests as the origin of that large group to which the name hypernephroma was given by Lubarsch, and the work of Birsch-Hirschfeld and Willms, who pointed out the embryonal origin of certain others, including the "mixed tumors," there is still lacking any definite and generally accepted basis for classification. The tide of discussion still swings back and forth over the theories of Grawitz, Sudeck, and Stoerk with regard to the epithelial group of tumors. A new note is struck in the work of Wilson, who, disagreeing with all three of the above, advances the theory that the so-called hypernephromata are not sprung from adrenal rests but from inclusions of nephrogenic tissue (primitive renal blastema) of the mesothelium, and offers the term "mesothelioma" for tumors of this type. Further attention will be paid to these theories under Pathogenesis. Notable attempts to classify tumors of the kidney are those of Albarran and Imbert,[3] whose monumental work was published in 1903, and in America, of Garceau[16] (1909). That with the progress of our knowl-

edge there has come a tendency toward simplification of terms will appear from their classification.

Albarran and Imbert divide the subject into:

1. Adenoma (tubular, papillary and alveolar).
2. Adenocarcinoma.
3. Epithelioma (ordinary and with transparent cells).
4. Lipoma and pseudolipoma (hypernephroma).
5. Sarcoma.
6. Fibroma and subcapsular fibrosarcoma
7. Mixed tumors.

Garceau offers the following classification for tumors of the renal parenchyma:

- Malignant
  1. Hypernephroma.
  2. Carcinoma.
  3. Sarcoma
     - Round cell, spindle cell (angiosarcoma).
     - Fibrosarcoma.
     - Liposarcoma.
     - Alveolar.
  4. Adenoma.
- Benign
  1. Adenoma.
  2. Angioma.
  3. Lipoma.
  4. Fibroma.

Since the publication of Garceau's work there have been many cases reported in the literature, the number of those reviewed by the author being 114, which are roughly grouped as follows:

Hypernephroma	43
Carcinoma	7
Sarcoma (of various types)	15
Embryoma (mixed tumors)	27
Adenoma (of various types)	10
Unclassified	3
Tumors of the renal pelvis	5
Tumors of the renal capsule	3
Tumors of the fatty capsule	1
	114

It will be seen that from the pathological anatomy no common basis of classification of malignant tumors can be deduced, nor is it of great importance from a clinical stand-point. Malignant tumors of widely varying structure are so uniform in symptoms and course that, of however great pathological interest, the precise point of origin in the embryonic mesoblast or the determination of the embryonic or metaplastic nature of a given tissue are not essential to the surgeon whose aim is early diagnosis and effective treatment.

The following somewhat arbitrary classification is therefore adopted as grouping together types of tumors which are associated either on a basis of pathogenesis or symptomatology:

I. Primary Tumors of the Kidney Parenchyma.

- A. Malignant
  - 1. Hypernephroma.
  - 2. Carcinoma.
  - 3. Adenoma, papillary cystadenoma and exceptional types.
  - 4. Embryonic tumors (Willms)
    - (a) Round-cell sarcoma.
    - (b) Spindle-cell sarcoma.
    - (c) Adenosarcoma.
    - (d) Mixed tumors.
  - 5. Teratoma.
- B. Benign
  - 1. Adenoma.
  - 2. Fibroma.
  - 3. Lipoma.
  - 4. Angioma.

II. Tumors of the Renal Pelvis.

- A. Malignant
  - 1. Papilloma.
  - 2. Squamous-cell carcinoma.
  - 3. Embryonal tumors.
- B. Benign
  - Papilloma.

III. Tumors of the Capsule.

IV. Tumors of the Adrenal Gland.

MALIGNANT TUMORS OF THE KIDNEY.

Hypernephroma.—Relative Frequency.—Owing to our present lack of uniformity in classification and nomenclature it is difficult to determine the relative frequency of the different types of malignant growths. A study of the tables given by the more important authors demonstrates the predominating number of hypernephromas, but other types appear in proportion of considerable variance. Israel's[20] table is as follows:

Hypernephromata and endothelial adenomata	17
Carcinomata	8
Malignant papillary cystoma	4
Sarcomata	4
Mixed tumors	2
Unclassified	7
Papillary carcinoma of renal pelvis	1
	43

Albarran and Imbert[3] have considered tumors in adults and in children separately. Their statistics bring out in striking manner the high proportion of hypernephroma relative to mixed tumors in adults and the reverse proportion of these two types in children. Their table is as follows:

	Adults.	Children.
Adenoma	10	5
Epithelioma	188	80
Hypernephroma	85	5
Sarcoma	82	80
Mixed tumor	10	49
Fibroma	2	
Lipoma	2	
Teratoma	1	1
	380	220

In a series of 114 cases collected by the author from literature published from 1909 to 1914 (inclusive) there appear the following:

Hypernephroma	43
Carcinoma	7
Sarcoma	15
Embryoma	27
Adenoma	10
Unclassified	3
Tumors of renal pelvis	5
Tumors of renal capsule	3
Tumors of fatty capsule	1
	114

In a series of 74 tumors at the Massachusetts General Hospital, collected by Barney,[4] the figures are:

Hypernephroma	27
Sarcoma	7
Carcinoma	7
Adenoma	3
Endothelioma	1

From the foregoing tables it is evident that in the great majority of tumors of the kidney in the adult the type is that now classified as hypernephroma or tumor of Grawitz. Albarran and Imbert alone place the largest number (188) in the class of epithelioma, but they draw a sharp distinction between the variations in form, as a result of which their proportion of hypernephroma is smaller than with other authors (85 out of 380 tumors). It would seem that a less narrow distinction today prevailed among pathologists and that certain tumor types classed by Albarran and Imbert as epithelioma would probably fall in the hypernephroma group. Next in frequency in most of the statistics are the sarcomata and "mixed tumors." Here again changing standards of classification have doubtless been responsible for the diversities in the different tables, and the term sarcoma is now less widely applied. The result is seen in the table of the author's collected series, where there are 27 embryomas to 15 sarcomas. Of tumors in children the large proportion of sarcomas of earlier tables are in contrast to later statistics, compiled since the embryonal origin of many tumors in early life has become recognized.

Pathological Anatomy.—1. **Hypernephroma.**—Although found at autopsy of such moderate or very minute size as to have been undiscovered during life, these tumors are found clinically as large as a hen's egg up to several inches in diameter.

Gross Appearance.—The striking feature of the external surface of the tumor is its irregularity in form and color. On removal of portions of adherent fatty capsule from the tumor, the latter is seen to be a single nodule of irregular or lobulated shape, the lobules of variable size, and of great variety of color. While the predominating color is usually yellowish, due to the presence of fat, varying shades of brown,

red or black, may be present, due to hemorrhage into the tissue. The tumor, if large, may stand out prominently from the surface of the kidney.

The consistency also is variable, from firm, where areas of fibrous tissue are present, to soft, where necrosis from pressure, or cyst formation, due to hemorrhage has occurred. The tumor if small may occupy one pole or the central part of the kidney substance, or may have grown to such size that the kidney substance is but a flattened shell at one part of the tumor's surface. The larger or more central the growth the greater will be its encroachment on the kidney pelvis, the resulting distortion of which is often marked. Frequently the growth is found to have extended into the renal vein, less often into the pelvic cavity, as a soft mass, yellow to brown in color. In rare cases the growth has been found to have invaded the ureter.

On section of the kidney, the tumor is seen to be more or less embedded in kidney substance, depending on its size; the kidney being often much flattened and reduced in volume in the case of large growths. The tumor is always surrounded by a definite layer of fibrous tissue, whitish in appearance, forming a constant line of demarcation between tumor and kidney tissue. The surface varies in color from a yellowish white or gray to red, brown or black. The lighter areas are formed of fat, fibrous or necrotic tissue, the darker ones result from hemorrhage into the tumor substance; which appears as fresh blood, more or less changed in color, or deposits of blood pigment in various stages of absorption. In its lighter areas the tumor resembles in appearance the tissue of the adrenal cortex. Rarely areas of calcification are found in the growth as in the case reported by Lorraine.[31]

While the smaller hypernephromata are completely surrounded by the fibrous capsule and must therefore be of benign nature, as the growth takes place the capsule is sooner or later broken through and invasion of kidney substance, of branches of the renal vein in the kidney or of the pelvic cavity takes place. Owing to this tendency to break through the capsule the tumor must be regarded as potentially malignant even in its earliest stage, and is therefore generally classified as malignant.

Microscopic Characters.—The smaller tumors, which have not undergone pressure necrosis or changes due to hemorrhage consist of the characteristic tumor cells, a stroma formed largely of capillaries and the fibrous capsule. The capillaries form a network upon which rest the tumor cells. These are arranged in groups or palisade forms, situated directly upon the capillary walls without intervening fibrous tissue. The rows are often two or three cells deep, and in some places the cells lie apparently free in the meshes of the capillary network (Fig. 249). The structure of the tumor cell is peculiar in its resemblance to that of the adrenal cortex. It is polygonal in form, slightly smaller than the adrenal cell, with pale or almost clear protoplasm, a distinct but delicate membrane, and a rather small nucleus (Fig. 250). The

PLATE VII

Hypernephroma of Kidney. Cut Surface.

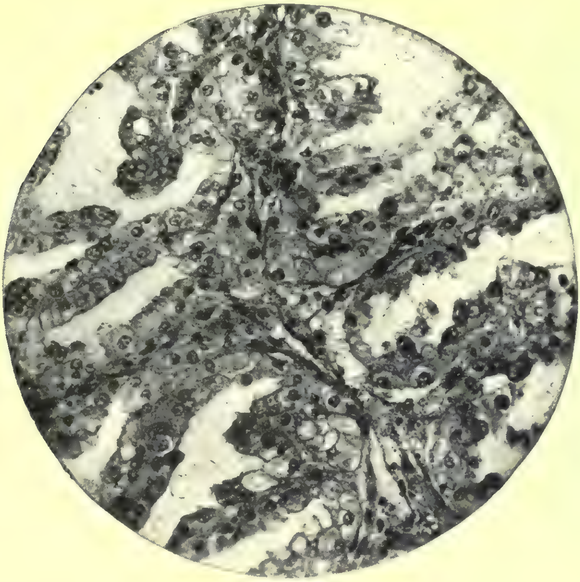


FIG. 249.—Hypernephroma of the kidney, showing papillary arrangement of the cells. These cells are arranged around capillaries. (From the laboratory of the Harvard Medical School.) (Garceau.)

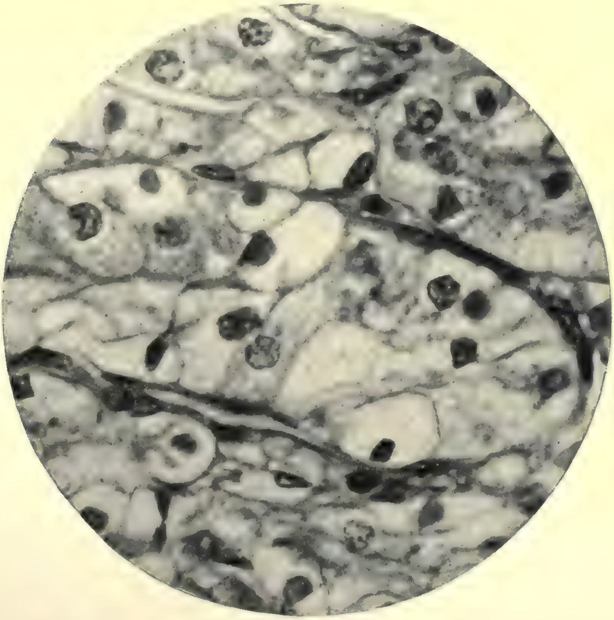


FIG. 250.—Hypernephroma of the kidney; fine detail. The polygonal cells are seen in the alveoli. (Watson and Cunningham.)

arrangement is sometimes alveolar, sometimes papillary. A striking feature is the frequent presence of fat droplets in the cells, to which the yellowish color of the tumor is due. Giant cells and karyokinetic figures are occasionally seen. In the tumors of larger size, the cells may be more densely packed, mosaic fashion, and the alveolar arrangement more marked, or when changes due to pressure or hemorrhages have occurred, necrotic areas of cystic cavities filled with changed blood or colloid material are present. The papillary arrangement is less common than the alveolar, Garceau observing, in 36 specimens, the papillary form in 14, the alveolar in 22. As in adrenal tissue, glycogen and lecithin are found in the tumor cells. Vacuoles are described by some observers as present in the cells, but these are explained by Ipsen[19] as due to the falling out of fat droplets from the specimen. The capillaries are more abundant in the periphery of the tumor. Grawitz found amyloid degeneration of bloodvessels present.

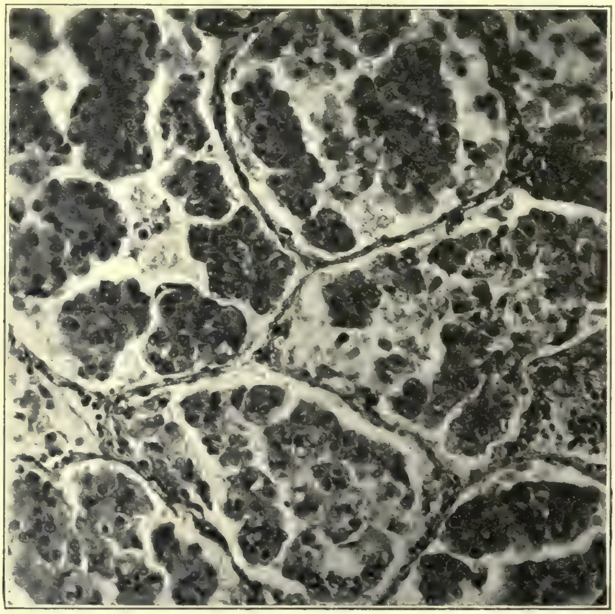


FIG. 251.—Metastasis in the lung of hypernephroma of the kidney. The alveoli of the lung are filled with branching papillary masses of tumor. (Watson and Cunningham.)

The fibrous capsule surrounds the smaller tumors but in the larger ones may be broken through by the tissue cells. It is generally regarded as consisting of an inner portion (capsule proper), and an outer layer of fibrous tissue formed by the atrophy of kidney tissue compressed by the growth, and containing remnants of glomeruli in places. (Albarran and Imbert.[3])

Metastasis occurs by entrance of the tumor into branches of the renal vein, or by direct extension through rupture of the fibrous capsule. The venous "thrombi" frequently break loose and are carried through the right heart to the lungs where the majority of the metastases are found. Small groups of cells may find their way into the general circulation, thus giving rise to metastatic tumors, which may appear in almost any organ of the body. Next to the lungs, the long bones are the most frequent site, and the first indication of the tumor may be spontaneous fracture. A not uncommon feature of the disease is the appearance of a metastasis before symptoms of the primary growth have been noted. The metastatic growth has the same appearance and structure as hypernephroma; hence its discovery in a tumor of bone, for example, signifies the renal origin (Fig. 251). Dissemination may occasionally take place by way of the lymphatics, as seen in cases of involvement of the regional retroperitoneal lymph nodes, the thoracic duct, or the peribronchial lymph nodes.

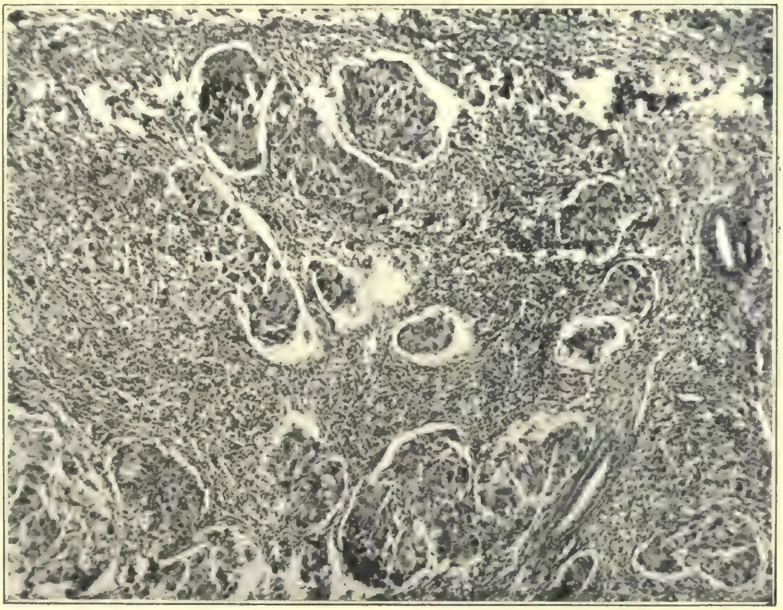


FIG. 252.—Carcinoma of the kidney parenchyma, showing arrangement of cancer cells in alveoli and masses. × 25. (Watson and Cunningham.)

2. **Carcinoma.**—That formerly many more cases of renal tumors were classed under this head than are so classed at the present time is evident from a glance at the statistics of different periods. Morris, in his table of 154 renal tumors gives 41 carcinomata. Israel, 8 in 43 tumors; and Albarran and Imbert have used a classification by which carcinomata outnumbers hypernephroma.

The writers of the past decade undoubtedly have classed a greater proportion of tumors under the latter head, so that the term is becoming limited to a group of tumors with definite characteristics. Garceau (1909) found but 3 carcinomata in 42 tumors occurring in ten years at the Massachusetts General and Boston City Hospitals. Swan[48] states that probably not more than 2 per cent. are carcinoma. The writer found 7 in 114 reported cases.

The irregular disposition of the cancer cells, their tendency to infiltrate the surrounding kidney tissue, and the lack of marked fibrous capsule are the basis for differentiating this tumor from the other malignant types (Fig. 252).

Gross Appearance.—The primary tumor, which is practically always unilateral, seldom reaches the large size of some hypernephromata or sarcomata. Deeply placed in the kidney it causes a general enlargement of the organ without great distortion. On cut section it appears gray, yellowish or reddish brown. It may involve the pelvis, and extension into the ureteral lumen has been found.

Microscopic Characters.—The tumor cells are usually of rather larger size than the hypernephroma cell, with granular protoplasm, and nuclei containing one or more nucleoli. They may be arranged in columns, or alveoli with surrounding fibrous tissue. In other places the cells lack definite arrangement but infiltrate the kidney tissues without any attempt at walling off. Lorraine[31] describes a tumor consisting of an outer wall of tissue of tubular structure but without any separation from kidney tissue. The central part of the tumor was a cystic and blood-filled cavity, into which papillary vegetations projected.

Metastasis takes place by either veins or lymphatics. Thrombi entering the renal vein produce secondary tumors in liver or lungs. Extension into the pelvis or ureter has been mentioned. The regional lymph glands, or more remote ones as the subclavicular or inguinal, may be involved. It is stated by Morris that while the primary tumor is yet small, the involvement of the glands along the vertebral column and at the renal pelvis may form a large mass, of which the tumor is a part.

Nicholson,[36] mentions a "nodular" form of carcinoma, always arising from the kidney capsule. That this may be of a type generally classed as hypernephroma appears from his non-acceptance of the Grawitz theory.

3. **Malignant Adenoma and Papillary Adenocystoma.**—(*Cystadenoma and Trabecular Cystoma.*)—A separate classification has been given to these tumors for the reason that they appear to differ histologically as well as clinically from infiltrating carcinoma. While bearing a close resemblance to benign adenoma they show malignancy in forming metastases. It is difficult to determine the frequency of these growths owing to the looseness of nomenclature in the past, and consequent confusion with other types.

Of eight adenomata or papillary cystadenomata reported in the

literature in the past five years three were definitely stated to be malignant. (Cases of Squier, Lenzmann, and Kretschmer and Moody.) Garceau mentions four "large papillary adenomata" among 42 tumors, at the Massachusetts General and Boston City Hospitals in ten years.

Gross Appearance.—The tumors recognizable clinically may reach a considerable size, and be single or multiple, usually near the capsule. The cut section presents a gray or reddish appearance with small areas of hemorrhage or cysts, the tissue being of soft consistency.

Microscopic Characters.—The cells may have a simple tubular arrangement (Fig. 253) or a striking papillary structure, springing from the walls of cystic cavities (Fig. 254). An alveolar form is sometimes seen.

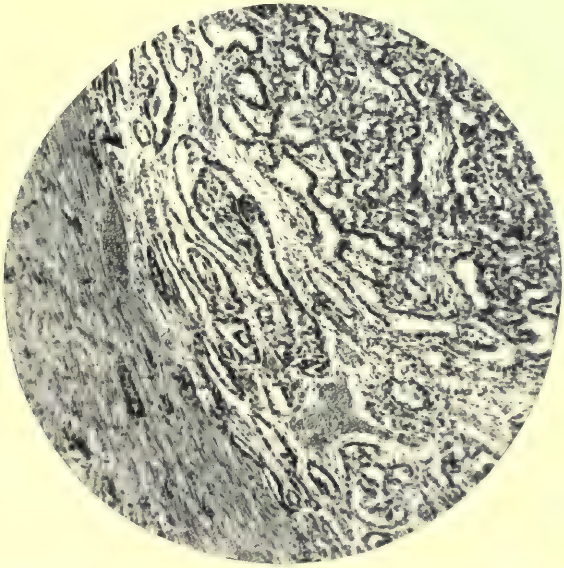


FIG. 253.—Tubular adenoma of the renal parenchyma, showing the arrangement of the tumor into tubules. (Watson and Cunningham.)

Mitotic figures may be present. In Kretschmer and Moody's case the tumor was in places hard and crackling on pressure, due to calcification of trabeculæ in necrotic areas. This was also present in the metastases. When cysts are present they are usually microscopic but occasionally they are large enough to be seen in gross, hence the tumor has been called cystadenoma or "trabecular cystoma."

These tumors differ from certain benign adenomata practically only in size, but are histologically identical. The fact that while they form metastases less often than hypernephroma or carcinoma, they nevertheless in some instances spread by direct invasion of surrounding tissue and form remote deposits in other parts of the body, entitles them to be classed as malignant. Garceau cites a case in which the tumor

thrombus extended from the right renal vein into the left and inferior vena cava for some distance. In Kretschmer and Moody's case the tumor was adherent to the liver, metastatic nodules appeared on the diaphragm, liver, stomach, surface of the mesentery, the mesenteric lymph nodes were involved, and the prevertebral glands formed a mass reaching into the pelvis.

FIG. 254.—Papillary crystadenoma of kidney, showing arrangement of the papillæ, × 125. (Watson and Cunningham.)

4. **Embryonal Tumors** (*Willms*).—(*Round-cell Sarcoma, Spindle-cell Adenosarcoma, Mixed Tumors.*)—Under this heading are grouped a variety of renal growths, many of which have been the subject of much controversy as to histogenesis and consequently shifted about in classification according to the author's personal views. "Endo- and perithelioma," "alveolar sarcoma" and "angiosarcoma" are among the terms formerly applied to certain ones of this class. Since the work of Hirsch-Birschfield, Willms and others threw a new light upon the development of tumors of the connective and "mixed" tissue groups, there has been a growing tendency to place all the malignant ones at least of these types under the head of embryonal tumors.

That the term "sarcoma," apart from any special histogenetic bearing, is giving away to others more exact from the stand-point of

origin, is evident from a comparison of the tables of Morris, Israel and others. Morris in 154 tumors, reported from 1884 to 1893, gives 63 sarcomata and no "mixed" tumors. Israel in 43 tumors quotes "sarcomata 4, mixed tumors 2." Albarran and Imbert (writing in 1903) quote 82 sarcomata and 10 mixed tumors in a table of 380 tumors. In a series of 114 reported cases from 1909 to 1914 collected by the writer there appear sarcoma 15, embryoma (mixed tumors) 27.

This comparison shows the general recognition today of the embryonal origin of tumors, formerly classed as "sarcoma." Reference to this point will be made in discussing the pathogenesis.

Relative Frequency of Different Types.—Of the writer's collected series an histological diagnosis was made in 31 cases classed as sarcomata or embryoma (mixed) tumors as follows: Small round-cell sarcoma 1, spindle-cell 3, adenosarcoma 1, mixed tumors 24. The two other cases were termed "polymorphocellular sarcoma" 1, and "lipoma of embryonal origin" 1.

Gross Appearance.—Although the three types of sarcoma are specified as being more common than other "embryomata" except the mixed, it should be understood that the other malignant forms of single tissue tumors (*i. e.*, "myoma") are included here.

The embryonal tumors may be single or multiple. Clinically the much more common form is a single mass, varying in size from a fist to a child's head or even larger. In children they may reach such proportions as to cause great protrusion of the abdomen, and Bland-Sutton[6] refers to one which weighed 31 pounds. They frequently are found weighing six or seven pounds.

The growth usually arises in the substance of the kidney, near one pole or the other, forming a more or less irregular mass, which may be smooth or nodular. At times the growth is chiefly in the pelvis. Bland-Sutton draws a distinction between "sarcomata" in infancy and in adults. He believes the former to develop from the normal tissues of the hilum and to have no "embryonic" derivation; in adults they develop in the cortex, usually from or near the capsule. His opinions are not confirmed by others. The outer surface may be smooth or nodular; multiple small tumors may give the kidney a marbled appearance. The tumor is moderately firm or soft. On section the growths are gray, grayish white, yellowish to pink in color, according to the type of tissue present. Hemorrhagic areas may be present, necrosis usually giving the tumor a yellow color. Softening due to cyst formation or myxomatous degeneration are not uncommon. The cyst may contain a gelatinous fluid. The growth may have a fibrous capsule, formed apparently from compressed and atrophied renal tissue. It invades the renal tissue as a nodular mass or less commonly as a diffuse infiltration. In the latter case it has been known to completely displace the normal parenchyma, the form of the kidney being preserved.

Metastasis occurs more commonly by direct invasion than by involvement of the veins (the reverse of hypernephroma). When of sufficient

size to break through the kidney capsule the growth involves surrounding organs and structures, such as the liver, spleen, diaphragm, intestine, etc. Metastases are found less often in the case of tumors in children than in adults. Walker[51] in an analysis of 142 cases of mixed tumors, found 55 cases with metastases, the liver and lungs being involved in 11 cases, the retroperitoneal glands in 10, mesenteric in 6, vena cava in 6 cases.

Microscopic Characters.—The more simple, so-called "pure" types will first be described. In spindle-cell sarcoma the tissue consists of bundles of fusiform cells running in all directions, with more or less round-cell infiltration. In places hyaline degeneration may have

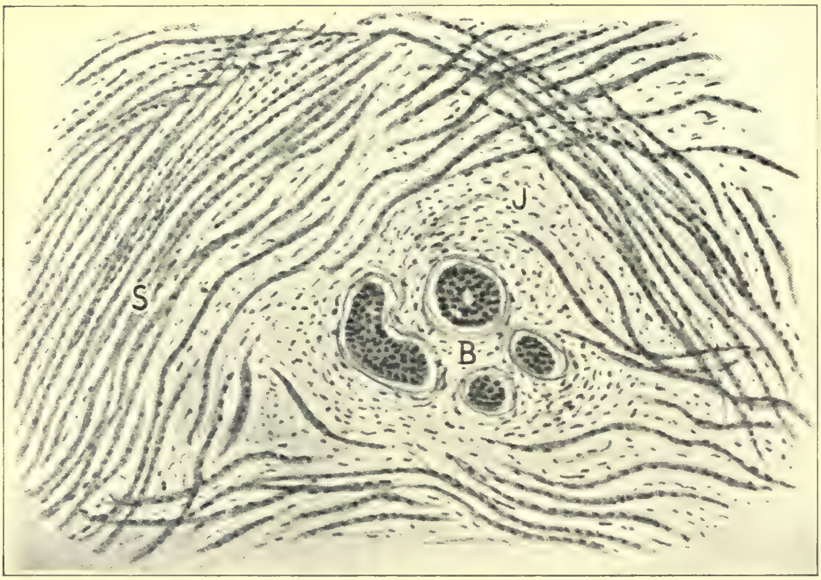


FIG. 255.—Mixed tumor of the kidney, showing striated muscle, stroma, and tubular structure. (Ribbert.)

occurred. The periphery presents renal elements undergoing pressure atrophy. Bloodvessels are not abundant. The *round cell* variety presents a tissue composed of small round cells, abundantly supplied with veins, the tissues at times showing large blood-filled spaces (Albarran and Imbert, p. 89).

Peculiar forms of "sarcoma," such as endothelioma, angiosarcoma, lymphangioma, perivascular sarcoma are merely mentioned here owing to their great rarity and presumable pathogenic identity with the more common forms. (Clinically they are not to be differentiated.)

The "*mixed*" tumors, including the simpler forms of myosarcoma, and rhabdomyoma, are more numerous and are of special interest. The tumors contain a variety of tissues resembling those in the embryonic

state, and at an earlier developmental stage than the teratoma or dermoid. Owing to the number of different tissues in them a great variety of names have been applied, based on the predominating kind of tissue. In general, the tissue consists of a diffuse cell-agglomeration or of gland formation in a stroma of more or less richly nucleated mesenchymal tissue. Throughout this stroma are found one or more of the following tissues: glands or tubules, smooth or striated muscles, fat, cartilage and bone. Spindle-shaped or round sarcoma cells may be intermingled with any of the above. A fairly frequent variety is that containing striated muscle tissue, and commonly termed (Fig. 255) "rhabdomyoma." According to Garceau sarcoma tissue is also present in these tumors in 12 per cent. of the cases. Tubular elements

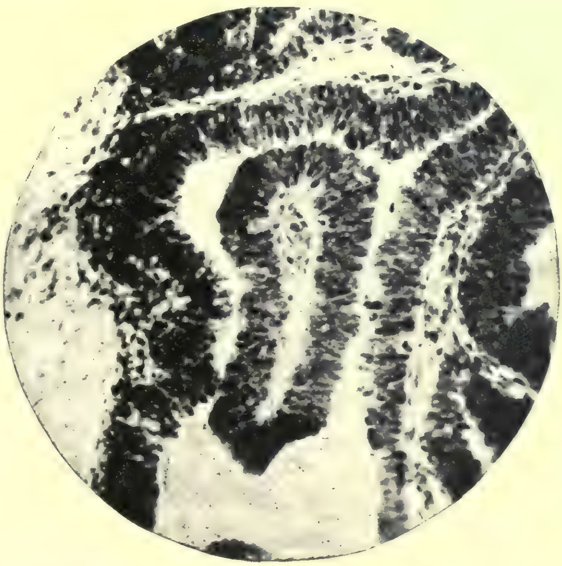


Fig. 256.—Embryonic mixed tumor of the kidney, in a child, aged one year and ten months, showing tubular structure. × 125. (Watson and Cunningham.)

were found in 50 per cent. of the tumors containing striated muscle analyzed by him, as depicted in Fig. 255. These tubular or granular structures (Fig. 256) appear as epithelial cells, in layers two or three cells deep, resting on a basement membrane. They bear no resemblance or relation to the normal kidney tubules. Budding and cyst formation are sometimes seen. The epithelial structures are usually in groups surrounded by connective, muscle or sarcoma tissue. Another form is that nearly resembling true ectodermal epithelium in that cornification ("pearls") appears (Fig. 257) in the tissue. The striated muscle fibers may be seen as scattered bundles throughout the tissue, or grouped about the granular elements. The smooth muscle, according to Albarran and Imbert, is often in relation to the bloodvessels, and may

in some cases be derived from the normal vessel wall. At times it is independent of the vessels, which are usually small and not abundant. Fat, cartilage and bony tissue appear in isolated masses.

Pathogenesis.—Hypernephroma.—In the introductory paragraphs allusion was made to the misconceptions regarding these tumors which existed previous to the work of Grawitz, and to the controversy, arisen since that time, over the acceptance of his theory of their origin, the result of which was that their confusion with lipomata was cleared up and the identity of the tumor established. Their origin from "adrenal rest" (Grawitz theory) has become a field of conflict among pathologists ever since Grawitz expressed his views. His theory is based on (1) the strong resemblance of the hypernephroma cell to that of the normal adrenal cortex; (2) the fact that minute bits of adrenal

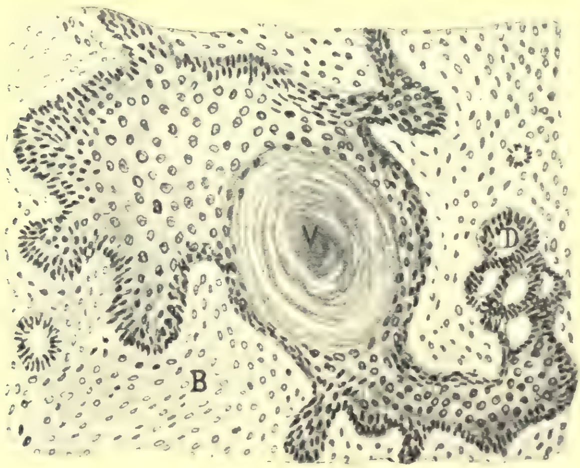


Fig. 257.—Mixed tumor of the kidney showing epithelial structures with central cornification and tubular structure. (Watson and Cunningham.)

tissue are commonly found imbedded in the kidney, especially beneath the capsule; (3) the presence of fat in the tumor cells, which is also a peculiarity of the adrenal cell; (4) the arrangement of the cells in relation to the stroma, similar to that in the adrenal; (5) the presence of a limiting capsule, which is also found surrounding the adrenal rests. Lubarsch and others, supporting Grawitz, have pointed out the similarity of hypernephroma to tumors of the adrenal gland itself. On the other hand, Stoerk, Sudeck and others have attacked the Grawitz theory, their chief argument being based on the presence of papillary and cystic formation in the so-called hypernephromata. These, they claim are not found in tumors of the adrenal gland itself but are characteristic of tumor arising from the true renal tubules; whence they argue, the hypernephromata are not derived from the adrenal rests but are of renal origin. In support of this, they point to

the frequently observed papillary and cystic formations present in senile and nephritic kidneys.

In this country Kelly[26] defended the Grawitz theory and pointed out the fact that metastases may reproduce the typical tissue of the zona fasciculata of the adrenal, although the primary tumor may present a different picture. More recently Kostenko[27] published the results of a careful study of renal and adrenal hypernephromata, in which he denied the soundness of Stoerk's and Sudeck's claims, showing that papillary and cystic formation may be found in hypernephromata of the adrenal gland itself and concluding that, for this reason and from the fact that chromaffin tissue is sometimes present in hypernephroma, its origin from the adrenal is probable.

Other authors, as Albarran and Imbert, and Ipsen[19] have attempted to subdivide the hypernephroma class into those of the "adrenal" and "renal" origin, without contributing toward settling the question. Wilson[54] has added an entirely new element to the question by advancing the theory, based on embryological study, that these tumors arise, not from the adrenal rests, but from included "islands of nephrogenic tissue." He offers the term "mesothelioma" as more correct.

Space does not permit a further discussion of the various arguments, pro and con, that have been advanced. It suffices to say that the majority of surgeons and pathologists today accept Grawitz's views as unrefuted.

Carcinoma.—Labourin[28] believed that the adenomata, benign and malignant, arose as a process of epithelial transition in chronic nephritis ("chirrose renale"). Albarran, in 1897, called attention to certain "pararenal" tubular masses resembling embryonic kidney tissue, often lying subcapsular, and thought they were the origin of some carcinomata. These tumors are so rare that no observer has had sufficient material to prove the soundness of any theory, but the distinctly epithelial character of the cells and the divergence of these tumors from hypernephroma on the one hand and the embryonal on the other make their origin from the renal epithelium most probable.

Malignant Adenoma; Papillary Cystoma.—The fact that these tumors are sometimes multiple in the kidney, and also that intermediate stages are seen between budding renal tubules and well-marked papillary structures, are considered by Albarran and Imbert as strong evidence of their renal origin.

Embryonal Tumors (*Sarcomata, Mixed Tumors*).—The study of renal embryology has brought this class of tumors into special prominence. Birsch-Hirschfeld, in 1894, called attention to the close relation of the Wolffian body to the primitive kidney tissue, and conceived the idea that in the embryo Wolffian body inclusions, becoming incorporated in the developing kidney, might be the origin of rhabdomyomas and adenosarcomas. Willms developed the hypothesis further, suggesting that the striated muscle had its origin in bits of myotome which became displaced and included in the kidney, bone and cartilage

having a similar origin from the sclerotome (vertebral anlage). The glandular elements he believed arose from the Wolffian body, while fibrous tissue, fat, smooth muscle, and vessels had their origin in the undifferentiated mesenchyma. Busse[10] attacked these views and advanced the theory of metaplasia in explaining the presence of striated muscle in the kidney, calling attention to the presence of striated muscle fibers in the adult uterus.

Other investigators have added little to these hypotheses nor have any approached that of Willms in ingenuity or completeness. The majority of sarcomas are today therefore explained by the hypothesis of Birsch-Hirschfeld, and the more complex and highly differentiated "mixed" tumors by that of Willms. While definite scientific proof is lacking, the fact that a large proportion of these tumors occur in children and have been found in the embryo (case of Paul, quoted by Wollstein[56]) furnish strong support to the arguments of Birsch-Hirschfeld and Willms.

On account of the many points of difference in the clinical aspects of malignant tumors in adults from those in children it is necessary in the following divisions of this section to treat them separately.

Etiology.—TUMORS IN THE ADULT.—*Frequency.*—The incidence of renal tumors in comparison with other diseases or with tumors in other parts of the body is given by the following observers: Reiche, in 11,930 cases of "cancer," 80 renal neoplasms, or 0.7 per cent.; Kelynack, in 1400 patients in the Manchester Royal Infirmary, 6 primary cancers of the kidney, or 4 per cent. Muller, in 521 cases of cancer, 3 of kidney, or 0.5 per cent. Squier[45] in twelve years at St. Luke's Hospital, New York, of 325 cases of surgical renal diseases found 24 renal tumors, 25 per cent. of which were hypernephromas.

In attempting to estimate the relative frequency of the different forms of tumor as given in the tables of the more comprehensive works, one is at once met with such diversity in classification that this attempt is futile. Authors presenting smaller groups of cases do not differentiate between adults and children. In the writer's collected series (1909 to 1914), excluding tumors in individuals under fifteen years, there were as follows:

Hypernephroma	43
Carcinoma	6
Embryoma	7
"Adenoma"	8

Age.—With regard to renal tumors in general the statistics of Albarran and Imbert are of value. Considering as "adults" all persons over fifteen years of age, they found the incidence by decades in 381 cases as follows:

16 to 25 years	31.7	per cent.
25 to 35 "	35.9	"
36 to 45 "	88.23	"
46 to 55 "	130.34	"
56 to 65 "	85.22	"
66 to 75 "	12.3	"

Other authors, as Senator and Kelynack, agree closely with the above. The fiftieth shows the largest number in any single year. Compared with infancy and old age the freedom in the earlier years of adult life from renal growths is striking.

Statistics as to the relative frequency of various types at different ages are meager. Garceau in 176 collected cases of hypernephroma found 133 falling between the ages of forty and seventy, but only 27 between twenty and forty years.

The following tables show the incidence by decades in the writer's collected series:

	Hypernephroma.	Carcinoma.	Sarcoma and "Embryoma."	Adenoma.
20 to 30 years	2	2	0	2
30 to 40 "	3	1	1	1
40 to 50 "	9	0	3	4
50 to 60 "	14	1	1	0
60 to 70 "	9	1	0	0
70 to 80 "	5	1	1	0
	42	6	6	7

Sex.—It is generally stated that the adult male is slightly more often affected than the adult female. The figures of Albarran and Imbert and Kelynack and Senator differ but little. More recent statistics are those given by Barney, who, among the cases at the Massachusetts General Hospital, found 43 males to 31 females (including cases in children). Braasch[8] of 83 cases at St. Mary's Hospital found 62 per cent. in males. In the writer's collected series, embryonal (mixed) tumors being excluded, there were 31 males and 28 females. It is of interest to note that in hypernephroma the figures are similar to those for all tumors. Keen, Pfahler and Ellis[24] found 71 males to 45 females. Garceau,[16] 102 males to 71 females. Specific estimates for the other varieties of tumors are based on too small a number of cases to be of importance.

Side Affected.—Primary tumors in the adult may be said to be always unilateral. The combined figures of Albarran and Imbert, Rohrer, and Kelynack show the right kidney affected in 260 and the left in 252 cases. There is no preponderance of one side in malignant renal growths, although in smaller series of cases this may appear.

Other Factors.—That heredity or traumatism plays any part in the etiology of malignant tumors is not apparent. The latter is mentioned in case histories no more often than should be expected. *Renal calculi* are occasionally found in conjunction with tumors, and the question of cause and effect naturally arises. Albarran and Imbert collected 26 cases in which stone was present. While a number of these were phosphatic and undoubtedly secondary, the not infrequent occurrence of large or multiple calculi in the pelvis is striking. Albarran and Imbert mention the case of a man, aged sixty years, whose renal symptoms began at the age of six. Nephrotomy and removal of 83 grams of phosphatic calculi from a large sac was followed by a development of

cancer in the wound, from which death occurred. The prolonged irritation existing in such cases may well be a factor in the production of cancer, as in other organs.

In a review of 140 cases at the Mayo Clinic of renal stone, Coryell[11] found 9 in which cancer was present also. From the study of these cases he concludes that there is a very constant inflammatory reaction accompanying renal calculi, which may be present in different parts of the kidney. In cases of cancer the neoplastic change was usually between the inflammatory and healthy tissues, and appeared at first as hyperplasia of the tubules, finally as actual newgrowth. The chronic irritation of the stone seemed to be the cause of the cancer. Of the cases of cancer studied, 64 per cent. were associated with stones.

Malformations (Horseshoe Kidney).—A few cases have been reported of renal tumor, occurring in a horseshoe or ectopic kidney. Albarran and Imbert and Morris, however, do not ascribe to malformations any importance in this connection. Young[57] reported a case of hypernephroma in an ectopic kidney, lacking a suprarenal. Wolff reported a hypernephroma in a horseshoe kidney which came to autopsy. The examination showed the suprarenal gland on the side of the tumor to be wanting, while the other was hypertrophied. He suggests an inclusion of the whole suprarenal gland in the horseshoe kidney as a possible explanation of the development of the tumor. Such coincidences are striking, but a sufficient number has not been reported as yet to give them any special etiological significance.

Symptomatology.—Since the symptoms and signs of renal growth differ so strikingly in adults and children, demanding a division of the subject, only the former will be discussed here. Unlike the constantly changing views and doctrines regarding pathology, our ideas concerning symptomatology have for many years undergone little or no change. The three cardinal symptoms of renal tumors in the adult—hematuria, tumor and pain—have long been so recognized, and it is equally well known that but one symptom may be present for a long period, in some cases, before further signs develop. Albarran and Imbert found the first symptom to be

Hematuria in 54 per cent.
Pain in 45 per cent.
Tumor in 20 per cent.

The successful treatment of renal tumor depending chiefly on early diagnosis, this consideration of early symptoms is of paramount importance.

Hematuria.—This is usually spontaneous, "total," and not of great severity at the outset. It is sufficient to attract the patient's attention either by the color of the urine or by the presence of clots, often of a worm-like shape. In rare instances vesical retention has resulted from large clots. If of sufficient size the passage of clots through the ureter will provoke renal colic, sometimes severe and prostrating. This usually subsides in a few days and the patient may go for months or

years before a subsequent attack. As the disease progresses the attacks of hematuria become more frequent and abundant. It has been shown that the bleeding may precede any involvement of the renal pelvis, due to congestion from pressure by the growth. The hemorrhage occurring when the pelvis has been invaded is likely to be more serious than when due to congestion. The duration of the period in which hematuria may be the only symptom makes it of special importance, particularly in hypernephroma. In a study of 83 cases Braasch found hematuria to have existed more than one year in 77 per cent.; and to be present in 64 per cent. It was the only symptom in 12 per cent. Others report cases in which bleeding antedated the operation by eight or ten years. Hematuria as a symptom occurred in 68 per cent. of the cases studied by Albarran and Imbert, the largest number being in cases of the hypernephroma group. In Garceau's series it was absent in 34 per cent. (hypernephromata), "proving that the tumor capsule prevents the escape of blood."

Pain.—This is variable in character, intensity, and duration. If due to bleeding it may be dull and constant from distention of the renal pelvis by clot, or colicky and intermittent if due to passage of clot or fragments of tumor through the ureter. It is of some importance as an early symptom, Braasch finding it the primary symptom in 32 per cent. of the cases, the only symptom in 17 per cent. It may be localized or radiating. In Braasch's series it was confined to the region of the affected kidney in 74 per cent.; present in both kidney regions in 6 per cent.; in the dorsal region in 17 per cent., and "general abdominal" in 12 per cent. When of sudden onset without apparent cause it may be due to bleeding within the tumor capsule. Pleschner[39] calls attention to this as a suggestive symptom in hypernephroma when there is also a sudden increase in the size of the tumor. It is then usually severe in character. Unlike that due to calculus it is independent of motion. It is neuralgic in character when due to pressure by the growth on the nerve trunks, and radiation to the groin, testes, thigh, or back is not rare.

In 74 cases Barney found it the most frequent symptom (63 cases), a higher figure than that of Albarran and Imbert, who found it in only 44 per cent. It is usually of shorter duration than other symptoms, patients seeking relief more promptly than when it is absent.

Tumor.—The anatomical position of the kidney is unfavorable for the detection of tumor at an early stage. Lying deep in the lumbar region, partially overhung by the lower ribs, it is natural that, especially in fat persons, small tumors cannot be palpated. The appearance of the tumor is not often an early symptom in the adult. It was found to be the primary symptom in 20 per cent. of the cases in the series of Albarran and Imbert, and also that of Israel. Braasch found the tumor a primary symptom in 15 per cent. and the only symptom in 6 per cent. Before operation is resorted to, however, clinical histories show tumor present in a large proportion. Among 303 cases Albarran

and Imbert found tumor present 255 times, or 84 per cent. This percentage held approximately for all types of malignant tumor. Garceau, in 176 hypernephromas, found tumor present in 143, or 76 per cent.

Tumors in the adult rarely reach the large proportions seen in children, but their size varies considerably. Israel claimed to have palpated a tumor the size of a cherry. The average size is not obtainable by statistics, but in a majority of cases the tumor reaches from the lower rib margin to or beyond the level of the umbilicus.

The form of the tumor is very variable. Infiltrating growths may replace the renal tissue so that the shape of the kidney is maintained and its size only altered. Growths in the upper pole may simply depress the body of the organ so that it simulates movable or floating kidney. Those more central may cause a prominence, smooth or rounded, or rough or irregular; the latter applies especially in hypernephroma. Those situated in the lower pole are more easily felt. If of sufficient size the tumor can be recognized by inspection, causing a more or less marked bulging of the lumbar and umbilical regions, and rarely of the epigastric. In adults the tumor seldom reaches the iliac region unless the kidney is prolapsed.

In the earlier stages, before local metastases have occurred, the kidney is movable, either with respiration, bimanual palpation, or ballottement. Fixity signifies extension of the growth into adjacent tissues, and is an unfavorable prognostic sign. Braasch found the tumor freely movable in 6 per cent.; slightly movable in 54 per cent., and fixed in 18 per cent. (15 cases, 12 of which proved inoperable). When ordinary bimanual palpation in the dorsal position fails, as may occur in fat persons, or those with tense abdominal muscles, the lateral position may assist, bringing the tumor into reach. In some instances an anesthetic has been necessary. Percussion yields a dull note except anteriorly, when the overlying colon is filled with gas. At times the empty colon can be felt as a cord-like object in front of the tumor, and colonic insufflation is confirmatory of the position of the tumor. When of sufficient size the tumor displaces the colon downward and inward. In the case of large tumors pressing upon great vessels, ascites and edema of one or both lower extremities has been noted. Dilatation of the superficial veins is a late symptom.

Symptomatic Varicocele.—Attention to this symptom was called in 1881 by Guyon. While not of frequent occurrence it has been present often enough to justify suspicion of renal growth, especially when present in a patient in or beyond middle life. It has been shown that involvement of the paravertebral lymphatic glands is not always necessary for its production; nor is it always present when the glands are involved.

Urinary Findings.—Unless hematuria exists or the tumor involves the renal pelvis in such a manner that tumor cells or shreds are set free into the urine the urinalysis may be negative. In some cases the

renal parenchyma may have undergone changes of chronic nephritis, due in part to pressure by the growth, and the urine from the kidney will be altered accordingly. The evidence obtainable by cystoscopy, functional tests, and pyelography will be discussed under Diagnosis.

Fever.—Fever of a moderate degree has been observed, Israel finding it is 8 per cent. It is not common, however, and was present only once in 25 cases of hypernephroma studied by Pleschner.

Elevation of Blood-pressure.—This has been reported in hypernephroma, but is still less frequent than fever. It is doubtless dependent on a nephritic process. That it may be physiological, due to an excess of adrenal secretion, absorbed in the circulation, is not probable.

Intestinal Obstruction.—Intestinal obstruction of varying degrees may occur when the tumor is of sufficient size to exert pressure on the gut or when there is a metastasis in the mesentery which encroaches upon its lumen. *Jaundice* has been noted in the case of a right-sided tumor pressing on the common duct.

Anemia and Cachexia.—Anemia and cachexia are late symptoms, developing, as rule, after other signs have indicated the nature of the disease.

Other Symptoms.—Anorexia, nausea or vomiting, dyspnea, or a dry cough (Braasch) due to mediastinal metastasis are symptoms occasionally mentioned. Hydronephrosis rarely develops, but has resulted from occlusion of the ureter by a fragment of the tumor, and by direct compression of the tumor mass.

Pulsation of the tumor or a *bruit*, audible with the stethoscope and synchronous with the pulse, have been noted. These symptoms have led to confusion with aneurysm of the renal artery.[25]

Diagnosis.—In the adult the diagnosis of a malignant renal tumor may be of the greatest difficulty. On the other hand, the typical case with hematuria of renal origin, characteristic localized pain, and a tumor occupying the region of the kidney, as shown by bimanual palpation and moving with respiration, in a cachectic patient, could hardly be mistaken. The complete picture was present in only 32 out of 83 cases in Braasch's series. He found only two symptoms in 37 cases; one only present in 14 cases. In obscure cases the only positive means of diagnosis may be the exploration of the kidney, which, as a last resort, is fully justifiable.

The conditions from which renal neoplasm is to be distinguished are those accompanied by one or more of its commonest symptoms, hematuria and tumor.

Grouped according to the most prominent symptom they are as follows:

(*a*) Hematuria:

"Essential" and nephritic hematuria.
Renal tuberculosis.
Renal calculus.
Floating kidney.

(*b*) Tumor:

Retroperitoneal tumors (glandular enlargements).
Tumor of liver.
Tumor of spleen.
Tumor of pancreas.
Hydronephrosis: pyonephrosis.
Bilateral cystic kidney, and serous cyst.
Cyst of the ovary.
Tumor of omentum.

"*Essential*" *and nephritic hematurias* are seldom as severe as the bleeding from renal tumor. Both are of rare occurrence, the former apt to be bilateral, as shown by the cystoscope, and the latter attended with other evidence of nephritis.

Renal tuberculosis occurs more commonly between the ages of twenty-five and thirty-five, the period when renal tumor is rare; is attended by more marked pyuria and a positive guinea-pig inoculation of the sediment established the diagnosis. The cystoscopic picture is usually characteristic in renal tuberculosis. In *renal calculus* the bleeding is rarely as severe and lacks the spontaneous character of that in tumor. The *x*-ray picture, or the passage of calculi, should be confirmatory. *Ureteral calculi* should be detected by the ureteral catheter.

Congestion of a *floating kidney* occasionally causes hematuria, but the mobility of the organ and the pyelograph should serve to distinguish it from tumor.

Group b. Almost any abdominal tumor, and certain pelvic, may at some stage resemble a renal tumor, so that the most careful study is essential for their differentiation. Important as are the ordinary means of physical examination, they may be insufficient. Cystoscopic diagnosis with ureteral catheterization and tests of the renal function, or pyelography may alone enable us to determine whether or not the kidney is involved.

Retroperitoneal lipoma or *sarcoma* are not only of great rarity, and usually of greater size, but they lack the definite lumbar position and outline of a renal tumor, the bulk of the tumor lying more central or lower than the kidney region. Tumors of the *lymphatic glands,* also rare, are usually part of a general process not difficult to discover. The growths arising from *liver, pancreas,* or *spleen* usually possess different relations to the abdominal wall and to the intestine, especially the colon. Hepatic tumors depress the transverse colon and closely approach the abdominal wall; pancreatic tumors and cysts are usually nearer the median line and are above the transverse colon. Splenic tumors, as a rule, displace the colon and stomach inward; the lower border touches the abdominal wall, in some cases having the characteristic outline. Renal tumors, on the other hand, rarely displace the transverse, and are either behind the ascending or descending colon according to the kidney involved, or displace them inward only.

Tumors of the *ovary* or *uterus* have been reported of such size and position as to cause doubt, but the history and pelvic examination should be sufficient to throw light on the origin.

Other renal conditions have been confused, the most common being *hydronephrosis* and closed *pyonephrosis*, both of which may be indistinguishable without the aid of the ureteral catheter. *Polycystic kidney* should be distinguished by its involvement of both kidneys and the presence of albumin and casts, and when hematuria occurs it is seldom to the same degree as malignant tumor. *Paranephritic* tumors, however, are often impossible to diagnosticate as apart from renal.

Cystoscopic Evidence.—The source of bleeding may be established not only during active hemorrhage by the bloody efflux from the ureter on the affected side, but later, after this has ceased, by the presence of a clot projecting from the orifice or by the congested and roughened appearance of the orifice. If the kidney is secreting but little urine the efflux will be sluggish, or if function has ceased the orifice may be atrophied. Fenwick and others have emphasized the importance of a dilated or varicose condition of the veins about the orifice, as extremely suggestive of renal tumor. Joly[23] reports a case in which a metastatic mass of hypernephroma was seen projecting from the ureteral orifice.

Evidence Obtained by Ureteral Catheterization.—Pyelography.—In any tumor of the kidney region ureteral catheterization may not only be of greatest service in diagnosis but is usually necessary for determination of functional capacity of the "healthy" kidney, on which the question of operation and the prognosis may wholly depend.

In a large number of renal tumors the comparative functions of the two kidneys will show recognizable differences. Pyelography likewise will frequently reveal a characteristic deformity of the renal pelvis in tumor cases, which is of the greatest value in determining the question of the renal involvement. The technic of these means of diagnosis will be found in another chapter. In 22 cases of renal tumor operated upon, Braasch found recognizable deformity of the pelvis by pyelography in 17.

The changes from normal may be of 5 types:

1. Retraction of the calyces, giving a "spider-leg" shadow.
2. Partial obliteration of the lumen, giving thin streaks in the shadow.
3. Irregular pelvic dilatation following necrosis or secondary infection.
4. Dilatation of the upper ureter, due to tumor surrounding it.
5. Abnormal position of the renal pelvis (lateral displacement).

Radiography, in the case of large or dense tumors, or in thin individuals, may furnish corroborative evidence and should be employed as a routine. Besides determining the presence of calculi, calcareous deposits of tuberculosis, etc., the *x*-rays may reveal the outline of the tumor mass, which is very suggestive, especially by comparison with the normal shadow, if obtainable, of the healthy kidney.

Diagnosis of the variety of tumor is, in the adult, generally uncertain by clinical means, with the possible exception of hypernephroma. Occurring in a large majority of all cases, and at times with the characteristic picture of repeated hemorrhages, pain and tumor, the diagnosis of hypernephroma is in such cases almost certain. When fragments of tumor can be found in the urine and examined microscopically all doubt is removed, as with the additional discovery of metastases, particularly in the long bones. Rapid increase in the size of the tumor and in the severity of the pain are also strongly suggestive. (Pleschner.) On the other hand, a tumor of large size with signs of extension into surrounding tissues, without marked hematuria but with cachexia, is probably carcinoma or sarcoma. Unfortunately in such conditions the diagnosis is made in an inoperable stage of the disease.

Course and Prognosis.—That the disease is often of slow progress, its onset marked by the appearance of only one symptom, and that a considerable period may elapse before the picture may become complete have already been pointed out. The duration of symptoms before the patient sought relief in the writer's collected series was as follows:

Hypernephroma (32 cases):

Under one year 15 cases, or 46 per cent.
1 to 2 years, 6 cases, or 18 per cent.
2 to 3 years, 5 cases, or 15 per cent.
3 to 4 years, 4 cases, or 12 per cent.
2 cases, five and seven years respectively.

Carcinoma (3 cases):

1 case, three months.
1 case, four months.
1 case, four years.

Embryonal Tumors (sarcoma: mixed tumors):

3 cases, under six months.
1 case, one year.
1 case, two years.
1 case, three years.

It is well known that the disease may progress for from several months to a few years before extension or metastasis develops, rendering the case beyond hope of cure. Of the above series 10 were recognized as inoperable. As the disease progresses hematuria, if present, becomes more severe and the pains increase as the tumor enlarges. Finally, signs of pressure appear in the form of intestinal disturbances, as nausea and vomiting, constipation, and enlargement of the superficial veins, varicocele, or edema of the legs. The disease terminates, as a rule, with cachexia, in some cases with uremia or pulmonary embolism. The hematuria may be sufficient to greatly exhaust the patient, but seldom is in itself the cause of death.

The duration of life from the appearance of the first symptom in 33 cases of "carcinoma" was found by Guillet, to be as follows:

Less than one year	6
One to four years	16
Four to ten years	5
Ten years and over	6
Total	33

Treatment.—That nephrectomy is today the only recognized treatment of malignant tumor of the kidney is well shown by the fact that in the writer's series (1909 to 1914) 41 operations were performed for the removal of the disease, and 40 of these were nephrectomies. These were not the work of a few surgeons but of twenty-two, American and European. No further proof is necessary that nephrectomy is the rule. The case forming the "exception," reported by Fabricius is of interest in that it was an hypernephroma, and was resected owing to an error in diagnosis. The patient, a man, aged fifty-five years, had complained for five years of sacral pain. On examination a tumor of the left kidney was found as large as a child's head. At operation it appeared to be a cyst of the lower pole of the kidney, of benign nature, and was therefore resected. Section showed it to be a necrotic tumor, cystic, the cavity filled with bloody fluid, and, under the microscope, traces of hypernephroma were seen in the wall. Undoubtedly this represents the rare condition of a tumor undergoing degeneration due to pressure of hemorrhage within the tumor itself. The intracapsular pressure resulting from the hemorrhage causes destruction of the tumor and the consequence is a tendency to spontaneous "cure." That actual cure by complete destruction might thus occur does not appear from the literature. In Fabricius's case the patient was reported well four years after operation, and it may be assumed that the hemorrhage and cyst formation in this instance tended to hinder extension of the growth and metastasis. It certainly cannot be argued from the result in this case that resection of malignant tumor is a safe procedure. Too many recurrences following resection are reported in the past, to convince us of anything but its futility. This holds true in cystic forms of malignant tumor as well as in the solid ones, large or small. The treatment is therefore total nephrectomy: the question then becomes one of method.

The methods differ fundamentally only in the routes of approach to the kidney, which are (1) the lumbar route, (2) the abdominal route, and (3) the combined route. As the minor details of the operation of nephrectomy are taken up in another chapter, only the points bearing on the treatment of renal tumors will be discussed here.

Lumbar Route.—This approaches the kidney retroperitoneally and is the one generally employed for the removal of small or medium-sized growths. The precise manner of making the incision varies with different operators, but in the majority of cases the oblique incision is generally to be preferred. This begins at the outer border of the sacrolumbar muscles, just below the twelfth rib, is carried downward and forward toward a point 3 or 4 cm. in front of the anterior superior

spine of the ilium. With small tumors, an incision five or six inches in length is sufficient, while in larger ones it may be prolonged as far as or beyond the point mentioned in front of the iliac spine. Still further prolongation parallel to Poupart's ligament is possible if it is found after division of the muscles that more room is needed in the lower part of the wound (Fig. 258).

On division of the subcutaneous fat and deep fascia the incision in its upper part divides transversely the outer border of the latissimus dorsi, then separates (or divides obliquely) the posterior fibers of the external oblique (Fig. 259), exposing the internal oblique muscle,

Fig. 258.—Oblique lumbar incision. (Kelly and Burnam.)

which, with the transversalis muscle beneath it, is then cut across. This exposes the transversalis fascia, which is opened in the upper part of the wound and divided on the finger or director, care being taken, as the incision is carried downward, to avoid the reflection of the peritoneum. The twelfth dorsal nerve should be avoided and drawn upward by the retraction of the upper margin of the wound, the ilio-hypogastric and ilio-inguinal should be out of danger in the lower margin of the wound.

The perirenal fat and fascia are seen bulging above. By following the quadratus lumborum muscle the kidney may be approached and the

outline and extent of the tumor determined. If the tumor extends well down and forward toward the iliac fossa the peritoneum must be carefully lifted from the fatty capsule and from the inner surface of the transversalis fascia, allowing the ascending colon and peritoneal reflection to be drawn forward out of danger, protected by gauze pads and held by retractors. A small freely movable tumor in the kidney

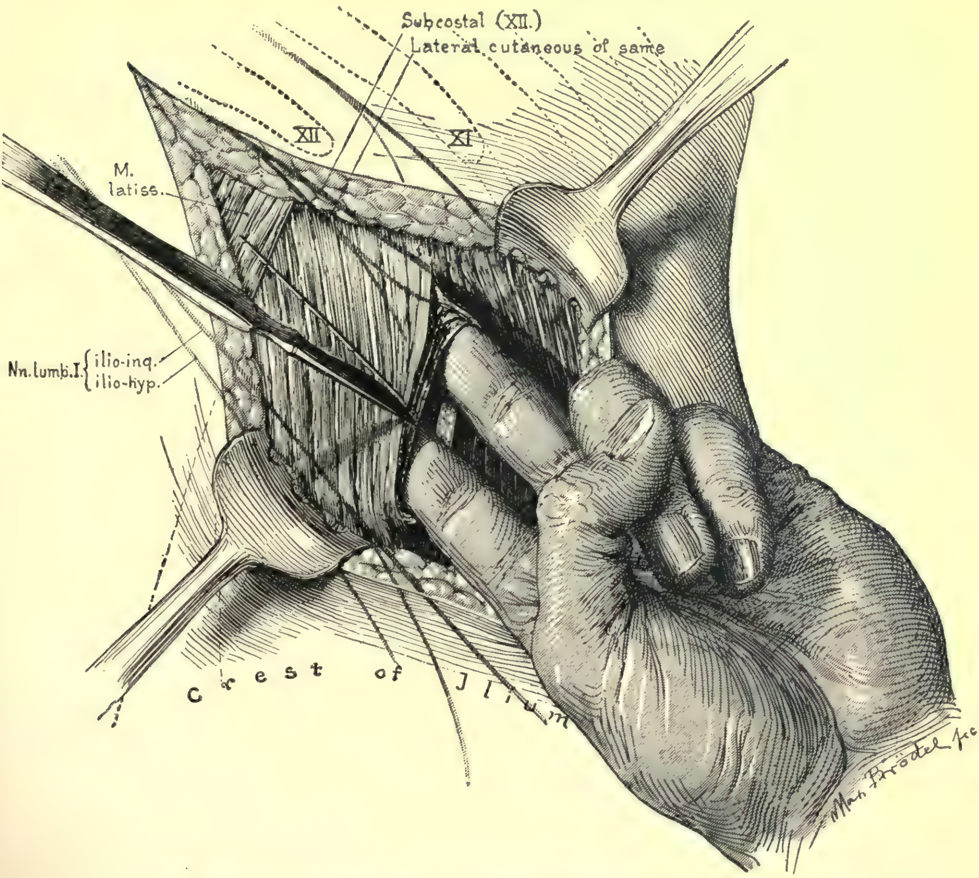


Fig. 259.—Oblique lumbar incision; division of external oblique muscle. (Kelly and Burnam.)

substance may then be approached through the fatty capsule, which is stripped off the tumor and kidney in the usual manner, the kidney being lifted into the wound until ureter and pedicle are developed, clamped and ligated and the kidney cut away.

If the fatty capsule is adherent this should be left on the kidney, as the adhesions may be due to extension of the growth into the perirenal fat. The peritoneum being carefully separated off in front and the

capsule lifted from its lumbar bed, the question of handling the pedicle then arises. Joly[23] opposes anything but a radical removal of the kidney and tumor within the unopened perirenal fat, with the suprarenal, adjacent lymphatic vessels, and glands in all cases of malignant tumor. This operation, first described by Gregoire in 1905 and known as the "complete operation," is based on the principle that tumor cells pass early through the lymphatics, from the renal cortex into the fatty envelope, where adhesions are formed by this extension of tumor tissue. Joly cites a case in which a single nodule was found in the fat free from the main tumor. He therefore advises that the dissection be begun below, outside the perirenal fascia (fascia of Zuckerkandl), the pedicle developed and ligated, but not divided until the juxta-aortic lymph glands are freed, which on the right lie in front

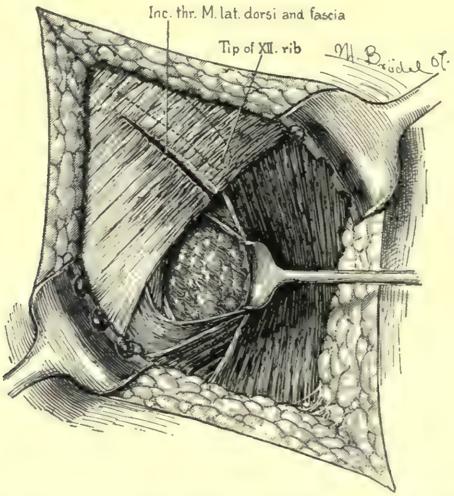


Fig. 260.—Muscle-splitting lumbar incision for exploration of kidney. (Kelly and Burnam.)

of the vena cava, on the left, close to the aorta. The removal of one suprarenal gland, he states, is not harmful in the human subject (although it is dangerous in animals). Care must be taken to secure the suprarenal artery. This operation would seem to be based on sound principles, as too often a "successful" nephrectomy for hypernephroma is followed by recurrence.

Whether or not the radical operation be done in the case of hypernephroma, the operator, having exposed the pedicle, should examine the renal vein for beginning invasion by tumor growth, and should divide it as far above the kidney as possible.

When a large and adherent tumor requires extra room above a subperiosteal division of the twelfth rib is effective. In some cases a trans-

verse incision forward, parallel to the rib margin, or below backward toward the quadratus lumborum is employed; these have the disadvantage of dividing nerves supplying the abdominal muscles. In case of very large growths in the upper pole the following incision has been used: Beginning at the outer edge of the lumbar muscles about an inch below the margin of the twelfth rib the incision is carried outward parallel to the rib and costal border, turning upward toward the epigastrium, terminating at the outer border of the rectus. By stripping away the peritoneum from the transversalis fascia, entrance of the abdominal cavity may be avoided. The incision allows upward traction on the ribs and a wide exposure of the kidney region.

Another similar one, recommended for large tumors, especially those in children, is the transverse lumbo-abdominal incision advocated by Abbe. This starts at the middle point of the outer border of lumbar muscles and is carried transversely forward to the rectus, in some cases meeting a short longitudinal incision at the outer border of the rectus muscle or in the linea semilunaris. Various modifications of the above incisions are employed to fit particular conditions. One, worthy of mention, is the "gridiron" or muscle-splitting incision only applicable for exploratory operations or the removal of the smallest tumors. This is similar to the oblique lumbar incision, first described, but the three abdominal muscles are divided in the direction of their fibers, and held apart by retraction above and below (Fig. 260). This affords room for exposure of the kidney for inspection and its removal if not enlarged, but should a growth of any size be found, further section of the muscles transversely to their fibers will be necessary.

Abdominal Route.—This incision enjoyed particular favor when it was thought necessary to examine the healthy kidney by palpation in the abdominal cavity before nephrectomy of the diseased. Today the information obtained by cystoscopy and ureteral catheterization removes the chief argument for this incision, and it is not surprising that many surgeons, to avoid the danger of peritonitis, prefer the lumbar route. In the author's collected series, in which 40 nephrectomies were performed, only 7 were by the abdominal route. This incision is made through the linea semilunaris or through the outer part of the rectus sheath. In case of a large tumor which has pushed the colon inward and downward it may be possible to draw inward the peritoneal reflection and the large intestine so that the peritoneal cavity is not opened, but, in the great majority of cases, the cavity is entered and the tumor found with the colon lying in front of it. The latter should be pressed inward, the reflection of posterior peritoneum divided at the outer colonic border, and the viscus dissected off the tumor, and retracted inward. This avoids injury to the colonic vessels in the mesocolon and danger of necrosis of the gut. On removal of the tumor, a drain to the kidney fossa should be placed through a stab wound in the loin, the posterior peritoneum sutured, and the abdomen closed with or without drainage.

Combined Route.—Morris and others have recommended the exposure of the tumor by a lumbar incision, combined with exploration of the other kidney, mesentery and retroperitoneal space (for glands) through the abdomen. Morris incises first the linea semilunaris, palpates the healthy kidney and explores the region of the tumor; then partially closes the wound, and turning the patient, makes the lumbar incision, approaches the kidney from behind and frees it as far as possible. The abdominal wound is then reopened, the dissection of the kidney continued from in front, the pedicle developed and ligated, and removed through the abdominal wound. He claims a great advantage in avoiding traction on the pedicle while freeing the connections of the tumor, and facilitating its removal anteriorly by a hand in the lumbar wound pressing from behind.

Choice of Route.—It has been already shown that today, in adults, the lumbar (extraperitoneal) is used much more often than the abdominal (transperitoneal) route. It is obvious that the chief advantage of the latter, exploration of the healthy kidney, is deprived of its weight, in the majority of cases, by modern methods of preoperative diagnosis. The lumbar route will therefore be that of election except in very large tumors, where the difficulty in handling the pedicle is great, or where the examination of the healthy kidney by cystoscopic methods has been for some reason impossible. Under these conditions, the transverse or abdominal incisions will be preferable.

As to the relative rates of mortality, the lumbar has usually shown a lower rate than the abdominal, but this is owing to the large size and more serious conditions attending the abdominal nephrectomies. Excluding operations upon children, Albarran and Imbert found the mortality rates for both routes about equal.

Contra-indications to Operation.—*Difficulties Attending Operation.*—With small tumors, movable with respiration or by bimanual pressure (ballottement), which have not formed adhesions to neighboring structures, the operation of nephrectomy is not difficult or immediately dangerous. Far different is it in the case of a large tumor which has extended into the fatty capsule, or glands about the hilum, or formed adhesions, through involvement of the fatty capsule with its muscular bed, the liver above, or the intestine. Such a tumor will necessarily be firmly fixed and the separation of its connections with surrounding structures attended with grave danger of their injury. Metastases or signs of extension—fixity, as determined by bimanual palpation especially, neuralgic pains along the course of the lower dorsal or upper lumbar nerves, pressure signs, as varicocele, edema, of the legs—are contra-indications which should caution the surgeon against operating with any hope of cure. If not immediately fatal, nephrectomy for malignant tumor in such cases will be followed by rapid recurrence; operation is here justified only as a palliative for intolerable pain, intestinal obstruction, or for hemorrhage of severe and dangerous character.

Operative Results.—*Immediate.*—In 143 collected cases Garceau found the operative mortality in nephrectomy for hypernephroma to be 30 per cent. Albarran and Imbert's series showed a mortality of 23 per cent. for lumbar nephrectomy, and 21 per cent. for transperitoneal in adults, including benign tumors. Squier[45] found the operative mortality in 24 cases occurring during twelve years and operated upon at St. Luke's Hospital, New York, to be 50 per cent. The list comprised tumors of both kidney and ureter, 6 being hypernephroma. Of 62 cases of malignant tumor at the Mayo Clinic, excluding 22 explorations in which the tumor was found inoperable, Braasch[3] found the mortality of the cases dying at the hospital to be 11 per cent. The difficulty of arriving at definite conclusions from a study of statistics, which include the period when early diagnosis by cystoscopic means was not developed as it is today, is clearly evident from the above figures.

Cause of Operative Deaths.—As might be expected, Albarran and Imbert found the majority of deaths following the operation were due to shock. This was naturally most frequent where extensive adhesions were present, and in subjects already cachectic or toxemic, with impaired cardiac and renal function. Israel called attention to a toxic injury to the heart muscle, especially in cases of metastasis into the veins.

Remote Results.—In Garceau's series of nephrectomies for hypernephroma, 43 recovered from the operation but died at varying periods as follows:

One year or less, 22 cases.
One to two years, 11 cases.
Two to three years, 6 cases.

Only 4 cases lived more than three years, 1 of these living for ten years. Of the 43 deaths, 33 were due to metastasis, in 1 case death being due to involvement of the mediastinal lymph glands ten years after the nephrectomy. Israel[20] reported 22 cases of hypernephroma in 14 of which death occurred *after* three years. It is evident that in this form of malignant tumor a three-year survival is not proof of cure. In a series of malignant tumors reported by Braasch the three-year "cures" were 27 per cent.; those living at the end of five years were 10 per cent. of the cases in which nephrectomy was performed.

Here again statistics are of little value since authors include all cases up to the time of publication. An estimate of the percentage, living at the end of five years, of the cases in which nephrectomy was performed up to one year or less from the date of publication tells but part of the truth. As Albarran and Imbert remark, figures have only a relative value because a large number of failures are not published. They conclude, from the study of a large number of statistics, that the number of "probable cures" is 28 per cent. in nephrectomy for renal tumor. (The late results of nephrectomy for embryonal tumors will be discussed in the following section.)

Malignant Tumors in Children.—The striking frequency of the occurrence of malignant tumors, especially of the embryonal type, in infancy and early childhood, demands their consideration separately from tumors in the adult.

Morris gives the following figures as to their frequency: of 132 cases of malignant renal tumors, 45 were in children. (Guillet.) In Albarran's series of 247 collected cases, 63 cases were in children.

Etiology.—While the maximum frequency is between one and five years a number of congenital cases have been published. Paul, quoted by Wollstein,[56] reported a case of bilateral adenosarcoma in a seven months' fetus. Albarran and Imbert found the greatest frequency between one and three years. In Walker's series the largest number fell in the first year, the second year coming next, the frequency gradually diminishing up to five years. From birth to six years his cases numbered 123, from six to fourteen years only 12. In the writer's collected series of 31 tumors, 17 occurred between the first and third years, 7 between the third and fifth years; the oldest was twelve.

Sex.—Males are affected slightly more often than females (White, Martin, Walker). Albarran and Imbert found 80 in males and 55 in females. Kelynack, however, found a larger proportion in females (36 to 30), as did the writer (17 to 9) in 31 cases, but in 5 the sex was not stated. In Walker's[51] series of 147 cases the left kidney was affected in 73, the right in 58, and both kidneys in 10 cases. In the writer's collected series the tumor was on the left in 14, on the right in 13 cases. Heredity plays an insignificant part in the etiology.

Symptoms.—The predominance of the embryonal type of tumor in children has been mentioned and explains the difference in the clinical picture from that in the adult, where hypernephroma is the prevailing type of growth. In 170 cases in children, Albarran and Imbert found 4 adenomas, 7 carcinomas, 2 "adenocarcinomas," 4 hypernephromas. The majority were "sarcomas" or "adenosarcomas" (embryonal tumors). The onset is marked in most cases by the appearance of the tumor, which, considering the rapid growth and relatively large size of the tumor, is not surprising. In the 31 cases of the writer's series, tumor was noted in all. Oftentimes the tumor increases several times in volume in a few weeks, sometimes almost filling the abdominal cavity, so that the wall becomes tightly stretched over the mass. Pain or hematuria is exceptionally the first symptom noted. Soon the signs of malignancy appear (anemia, emaciation), and pressure signs, as enlargement of the superficial abdominal veins, disturbances of digestion, and ascites. In Walker's series of 90 cases the onset symptom was tumor in 38, pain in 14, general weakness in 10, vomiting in 8, icterus in 2, diarrhea in 1, constipation in 1, ascites in 1, and cough in 1. Albarran and Imbert noted as the first symptom tumor or abdominal enlargement in 71 per cent., pain in 20 per cent., and hematuria in 5 per cent. In the earlier stages the physical signs relating to the tumor will resemble those in the adult. It appears as a smooth or

nodular mass in the hyperchondrium, dull on percussion, with the colon in front of it in the early stages, shown by a zone of tympany. Later the colon may become so flattened out by pressure that this sign is lacking. Its mobility diminishes with the increasing size. The pain when present is usually dull and continuous unless colic is produced by blocking of the ureter with a blood clot. Occasionally severe neuralgic pains result from pressure on the intercostal or lumbar nerves. Hematuria is rarely severe, usually intermittent when it occurs. In the writer's series it was noted but four times. Only once in the 31 cases were tumor, pain, and hematuria associated.

The *course* of the disease is characterized by the rapid enlargement of the growth, with the development of the signs of pressure and malignancy noted above. In the writer's collected series the duration of symptoms before relief was sought was:

Under six months, 16 cases.
Six months to one year, 5 cases.
One to two years, 1 case.
Two to three years, 0 cases.
Over three years, 1 case.

The extreme malignancy of the disease is shown by Garceau's figures. Of 24 cases, surviving nephrectomy, 11 lived less than seven months, 4 lived one year, and 1 lived two years. Death results ordinarily from cachexia, arising from effects of the growth proper, as metastases is not common. Uremia, or intercurrent diseases, are occasionally the cause of death.

Diagnosis.—Conditions likely to be confused with renal tumor have been discussed under Tumors in the Adult. A rapidly growing tumor in the lumbar region in a child, perhaps with the history of hematuria, and with signs of cachexia is not difficult of diagnosis. Of the conditions causing possible confusion in children, malignant disease of the retroperitoneal glands, splenic enlargements, hydronephrosis and tubercular peritonitis are the most important. The different position and formation of glandular tumors, the slower growth and characteristic shape of splenic tumor, and the absence of cachexia in hydronephrosis should serve to differentiate them. Tubercular peritonitis may offer considerable difficulty, demanding exploratory operation. Cystoscopic evidence is usually not obtainable owing to the patient's age, but in older children, the source of bleeding or the lack of function in the diseased kidney may be thus demonstrated and the diagnosis confirmed.

Tumors of the liver are rare in children, and are usually recognizable by their more median position, mobility, and by the sharp lower edge of the liver. When icterus occurs in a right-sided renal growth, differentiation is less easy. An hepatic tumor lies in front of or above the colon, a renal more behind it.

Tuberculosis of the kidney in infants is rare unless part of a general process. The smaller size of the tumor, pyuria, and presence of the bacilli in the urine facilitates the diagnosis.

Tumor of the bladder is also rare in children, and would only be suspected in those cases, almost exceptional, where the renal tumor cannot be palpated. Here bimanual rectal or vaginal examination—under anesthesia if necessary—should reveal a tumor of the bladder of any size. With older children the examining cystoscopes of small caliber, now in use, will be of the greatest value.

Treatment.—The dangers of delay in removal of an operable tumor, and the uselessness of operation except in the early stages, before the tumor has become firmly adherent, or metastasis begun, are even greater than with tumors in the adult. As in the adult the general condition of the patient, presence or absence of cachexia, of metastasis, and the functional capacity of the remaining kidney are the criteria on which the question of operation will be decided. Size of the tumor alone is not necessarily an important factor in the result, as cases of the successful removal of large growths are not unknown. Abbé removed a seven and a half pound "mixed" tumor from a year-old infant in 1902, and reports the patient as well ten years later. He performed resection of the tumor, which involved the upper pole.

As to route, the narrow space between ribs and iliac crest in children and the usual relatively large size of the growths are important objections to the lumbar (extraperitoneal) route, and it is therefore natural that the abdominal (transperitoneal) route should be more frequently employed than in adults. The different incisions and their technic have been already discussed in the previous section. It should be borne in mind that the dangers of shock and hemorrhage are usually greater than in adults. Every means should be used to prevent shock, special attention paid to the securing of vessels, and if the application of ligatures is too difficult or time-consuming, clamps may be left in the wound to be removed later. The value of blood transfusion before or after the operation must be remembered.

Results of Operation.—Not many years ago the mortality rate of nephrectomy for infantile renal growths was so high as to make non-interference almost the rule, but in recent years earlier diagnosis and improved technic has greatly reduced the percentage of fatalities. In 122 cases occurring from 1890 to 1902, Albarran and Imbert found an immediate mortality of 24 per cent., which, however, they consider a low estimate. Comparing the two routes, abdominal and lumbar, in 101 cases they found the rates as follows:

Abdominal route, 26 per cent. mortality.

Lumbar route, 28 per cent. mortality.

The greater difficulty of removal by the latter route, excepting in the smallest tumors, accounts for the difference in these figures. The greater success obtained by early operation is shown by Albarran and Imbert's findings in 41 cases, two years of age or less, with 5 operative deaths and 36 recoveries; 7 of these being well from six months to three years after operation.

Recurrence is very common according to most statistics. The great

majority of recurrences occur in the first six months, but their occurrence as late as four or five years has been reported. Albarran and Imbert's figures as to the actual percentage of deaths from operation or later recurrence are not conclusive, but they estimate this to be at least 75 per cent. Other authors, as Walker, placed it even higher. In the writer's collected series of cases from 1909 to 1914 inclusive the results of treatment were as follows:

Nephrectomies	22
Partial nephrectomies	1
Operative deaths	1, or 4.3 per cent.
Total mortality	34.0 "
Later deaths	6, or 27.0 "
"Cure" at two years	1
"Cure" at three years	1
"Cure" at ten years	1 (partial nephrectomy).
Not traced	13

While this series is too small for definite conclusion to be drawn from it, it is suggestive that the results of the past five years are an improvement over those preceding, and offers encouragement for the future lowering of the mortality rate in this disease.

BENIGN TUMORS OF THE KIDNEY.

The rarity of benign renal neoplasms is well known, restricting the term to tumors of surgical interest. Adelbert, in 51 cases, found 48 malignant and 3 benign—about 6 per cent. The minute fibrous or adenomatous nodules which are found in kidneys at autopsy, sometimes hardly visible in gross, are of purely pathological interest; only those tumors which attain a size sufficient to cause symptoms or to become demonstrable by palpation concern us here. This group of tumors is practically confined to (1) adenoma, (2) fibroma, (3) lipoma, (4) angioma, (5) teratoma (dermoid).

While sporadic cases of other types are reported they are either of no surgical interest, as, for instance, the lymphangioma mentioned by Morris, or are, in the light of our present knowledge, potentially malignant and have therefore been included under Malignant Tumors. Examples of these are the simpler forms of mixed tumors. That there has been much confusion in the past over the classification of these growths needs no emphasis. Morris, in speaking of the prognosis of *benign* tumors of the fibrous and fatty variety, says it is good in the above cases but "not so when sarcomatous or myxomatous elements are combined with the fibrous and fatty tissue." Strictly speaking, such tumors should not be classed as benign, but would more properly belong to the embryomata. In some of the adenomas the dividing line is very difficult to determine, especially in the papillary forms. It seems best, therefore, to follow the classification indicated in the first section, considering the papillary adenomata as potentially malignant, and including in the benign group tubular and cystic forms only.

Pathological Anatomy.—Adenoma has been referred to in the previous section (see Fig. 253, p. 613). It occurs as a tubular or alveolar formation, situated in the kidney substance or beneath the capsule. It is hard or soft, varies from gray or yellow to pink in color, and may reach the size of a child's head. (Morris.) The simpler forms consist of tubules or alveoli lined or filled with epithelial cells, which may become hyaline, colloid, or fatty. They may possess a fibrous capsule or the tissue lies in direct contact with the renal parenchyma. Cyst formation appears to be common and hemorrhagic extravasation takes place at times. There are many transitional forms between the simple and malignant papillary adenocystomata. (See previous section.)

Fibroma.—Fibroma while not rare in the form of small nodules often multiple, and found at autopsy, is seldom seen as a tumor of surgical importance. Of the 14 studied by Garceau none were recognized clinically. Albarran and Imbert found in a list of 380 tumors only two fibromata and the same number of lipomata. The pure fibromas may reach a large size; in Bruntzell's case (quoted by Garceau[16]) the tumor weighed twenty pounds. Morris refers to a case in which the kidney has been replaced by a fibroma growing within the capsule, as large as a child's head, consisting of very hard, "translucent" fibrous tissue. The other cases mentioned by him are probably the result of degeneration in growths of a different nature.

Lipoma.—Lipoma is also very rare as a primary growth. Fatty degeneration occurring in tumors of a different type must not be confused with the true lipoma. There may be a variable amount of fibrous tissue in the tumor. In one case mentioned by Morris the tumor weighed two pounds. The tumors may be multiple.

Angioma.—Angioma is often classed as a true tumor, but there is a tendency among pathologists to consider it as a malformation. As elsewhere in the body it has the structure of a nevus, but is rarely seen in the kidney. In gross it appears as multiple red, spongy masses which microscopically are composed of a collection of vascular spaces of variable size. Morris mentions a case in which ulceration into the renal pelvis occurred, causing hematuria.

Teratoma (Dermoid).—This term has frequently been applied to "mixed" tumors of embryonal nature, discussed in the previous section. It seems better to confine it to those tumors, rarely met in the kidney, which correspond to dermoids of the ovary. They are of extreme rarity, and Williams[53] was able to collect but 6 cases in the literature. Their structure is of adult tissues, as in the ovarian dermoids, hair, teeth, bone, or nerve tissue. The tumor may be adherent to or replace the kidney. Dermoid (piliferous) cysts are less rare. These contain besides hair a grumous material containing fat, epithelium, and degenerative products.

Symptoms and Diagnosis.—The lack of evidence of cachexia or metastasis and slow growth are the only features of benign tumors

which serve to distinguish them clinically from malignant. While there will be no marked symptoms in the early stages, as the growth enlarges and becomes evident there is usually some pain present. This may vary from backache or lameness in the loin to severe pain.

Hematuria is not common nor as severe, when it occurs, as with malignant tumors. When of sufficient size the tumor will produce pressure symptoms, edema, varicocele, constipation, and gastric disturbance. When of small size the diagnosis will be practically impossible, except when the kidney is exposed in an operation for some other condition than tumor. In case of larger tumors the same points apply in the diagnosis which have been mentioned under Malignant Growths. A very large tumor may be confused with ovarian tumor.

Treatment.—While benign tumors have been known to exist for many years the same is occasionally true of the malignant, and with this resulting uncertainty of positive diagnosis, they should be removed when the diagnosis of renal tumor is made. The growths of small size, accidentally discovered, or of moderate size, may be removed by partial nephrectomy, with closure of the wound in the renal parenchyma. Large growths which have caused atrophy or destruction, by pressure, of the kidney substance are best treated by nephrectomy. While the lipomata have a tendency to recur, the prognosis after removal is naturally good.

TUMORS OF THE RENAL PELVIS AND URETER.

Secondary growths involving the renal pelvis and ureter in tumors originating in the kidney proper have already been referred to. Primary tumors in this situation are rare, Israel[20] finding 2 cases of tumor of the pelvis to 68 of the parenchyma. In the writer's collected series reported from 1909 to 1914 there were 5 tumors of the renal pelvis to 105 of the kidney. The primary tumors of the ureter are extremely rare.

Pathology.—The primary tumors of the pelvis and ureter of more common occurrence are papilloma, papillary carcinoma, and squamous-cell carcinoma. Less common are tumors of connective-tissue or embryonal origin (sarcoma and the mixed tumors). Morris includes in tumors of the ureter the minute cysts, of which a few cases have been reported, frequently distributed throughout the ureter. These are probably not true tumors but retention cysts of the ureteral glands.

Papilloma.—This is the commonest form of primary growth in the pelvis or ureter, 22 out of Albarran and Imbert's series of 54 cases being of this type. More commonly it arises in the pelvis and involves the ureter, but it may originate in the latter. Metastasis in the lower end of the ureter has been seen with tumor of the pelvis. Recurrence (ureteral) after nephrectomy for renal tumor has been noted in 3 cases by Albarran and Imbert. The extent of the involvement in the ureter varies from a small portion at either end to dissemination throughout

its length. Simple papilloma rarely if ever produces enough enlargement of the pelvis to be demonstrated clinically. When, however, the upper ureteral orifice is involved or occluded, hydronephrosis results, as may happen also with the tumor of the ureter. The appearance is that of papilloma of other mucous membranes. The growth consists of villi having a small central vessel around which are arranged many layers of epithelial cells. A delicate stroma may be seen about the vessels. Sometimes the growth consists of a general villous change of the mucous membrane. The former type is more common (Fig. 261). The growth is confined to the mucous membranes in the typical benign

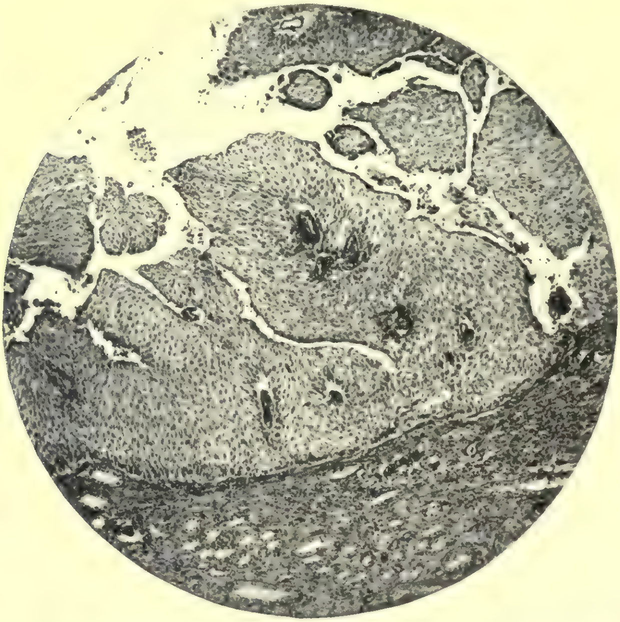


Fig. 261.—Simple papilloma of the renal pelvis, showing the papillary arrangement of the growth. Small bloodvessels traverse the centre of the papillæ, and around these vessels the tumor cells are arranged. (Watson and Cunningham.)

cases. It is generally agreed that malignancy may occur by invasion of the submucous layers, and a papilloma must therefore be considered potentially malignant. Albarran found in 42 cases of tumor of the ureter 18 papillomata, but believed only 6 of these to be primary. Fenwick reported a case of villous papilloma of the right ureteral orifice which was removed and a year later the right kidney was found to be the site of carcinoma.

Papillary Carcinoma.—It is probable that this is the stage of malignancy of the simple papillomata described above. Beginning as a papillary tumor on the surface of the mucous membrane, the growth gradually extends into the pelvic wall and frequently into the

substance of the kidney. As happens with papilloma elsewhere the tumor when removed may appear benign, only to be followed by a malignant recurrence. These tumors rarely reach a large size, as they cause so much bleeding that early removal is the result.

Squamous-cell Carcinoma (*Non-papillary Epithelioma, Epidermoid Cancer*).—This type of growth is still less common than the preceding. Its essential characteristic is infiltration into the pelvic wall, with secondary involvement of the kidney and ureter. Usually arising in the pelvis the growth has been reported as primary in the ureter. In

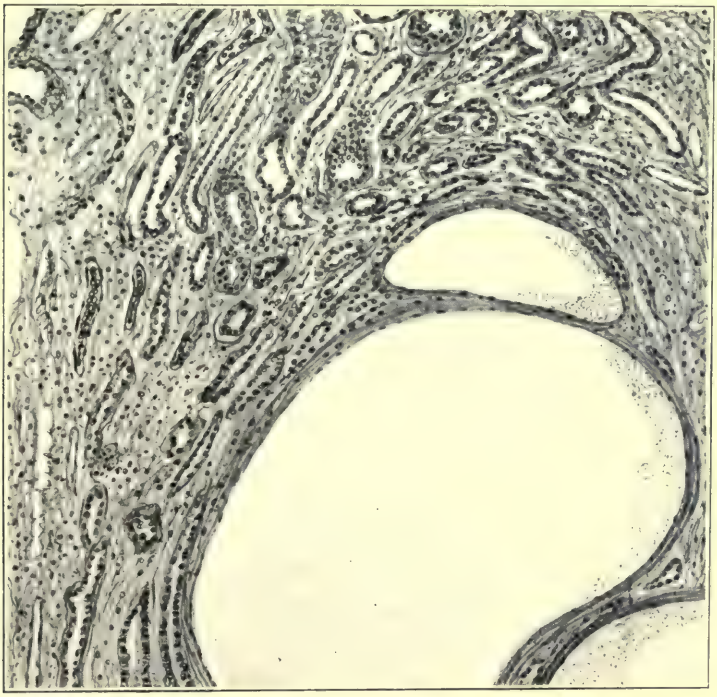


Fig. 262.—Microscopic section of a polycystic kidney. (Watson and Cunningham.)

the case reported by Rundle of the involvement of the lowest three inches of the right ureter with secondary deposits scattered up to within one inch of the pelvis, many metastases in the liver, lungs, and lymphatic glands were found. Hydronephrosis is the rule, and, combined with hematuria, leads to the diagnosis of renal tumor. The carcinoma of the pelvis or ureter will present thickening and hard infiltration characteristic of the growth, and in some cases the ureter becomes a thickened cord. The microscopic appearance is of squamous-cell carcinoma, in some cases the cell being of cylindrical type. The growth has often an alveolar arrangement. The possibility of squamous-

cell carcinoma arising from a preceding leukoplakia is suggested by Albarran.

Embryonal Tumors and Other Forms.—Other types of pelvic or ureteral tumor have been reported, but are so infrequent as to be almost unique. However, cases of adenocarcinoma were found in the literature by Garceau. Fischer and Murikami[14] report a case of mixed tumor of the renal pelvis which they consider to be due to a Wolffian rest. Two cases of sarcoma were reported by Morris.

Metastasis.—With the exception of simple papilloma these tumors of the pelvis and ureter are extremely malignant, besides having a tendency to disseminate both upward and downward in the urinary tract; the involvement of the neighboring lymph glands is common, and remote glandular metastases have been found as well as in the liver and lungs.

Association with Renal Calculi.—The presence of calculi in connection with tumor is occasionally noted. Morris found 9 cases reported by Drew, in a number of which the growth was not recognized at the time of removal of the calculi. He found 3 other cases of carcinoma in the literature associated with calculus.

Pathogenesis.—Except for the association with calculus as the exciting cause the origin of pelvic and ureteral tumors is obscure. Rare instances of mixed tumors are doubtless of embryonic origin. The possibility has been mentioned of leukoplakia, of inflammatory origin, being the starting-point.

Etiology.—The disease is essentially one of adult life, the majority of the cases being between the ages of thirty-five and sixty. Males are affected slightly oftener than females, the right side a little more frequently than the left. Fischer and Murikami's case of mixed tumor occurred in a girl, aged sixteen years, and there was a history of trauma a year before.

Symptoms.—The clinical picture is that of renal neoplasm, except that in the great majority of cases the tumor is due to hydronephrosis. Stusser,[47] analyzed 32 cases in the literature in which hematuria was present in 29, tumor in 25, pain in 16 cases. Hematuria is intermittent and painless, as a rule, gradually increasing in quantity and giving rise to clots which may be painful. The clots are usually worm-like, sometimes of great length. The case reported by Morris showed an unbroken clot thirty-nine inches long. In the benign tumors hematuria may exist for several years. In some cases the cessation of bleeding is accompanied by increase in the size of the renal tumor due to blocking of the ureter by a blood clot, an important diagnostic point. The tumor itself, when palpable, is indistinguishable from renal growth. Pain is the first symptom in about one-third of the cases, and becomes an important sign. It is dull in character and localized to the kidney region, or colicky and radiating to the bladder when due to clots. Bladder symptoms may be absent unless frequency is excited by the same cause.

In malignant cases anemia and cachexia become prominent in the later stages.

Urinary Examination.—Aside from the presence of blood no important changes commonly occur. Tumor fragments, occurring as villi or masses of tumor cells, may occasionally be found, but are not distinguishable from those due to bladder tumors.

Cystoscopic Evidence.—Even when the source of the bleeding is not determined by the presence of a visible discoloration of the ureteral efflux the appearance of the orifice may show a characteristic alteration.

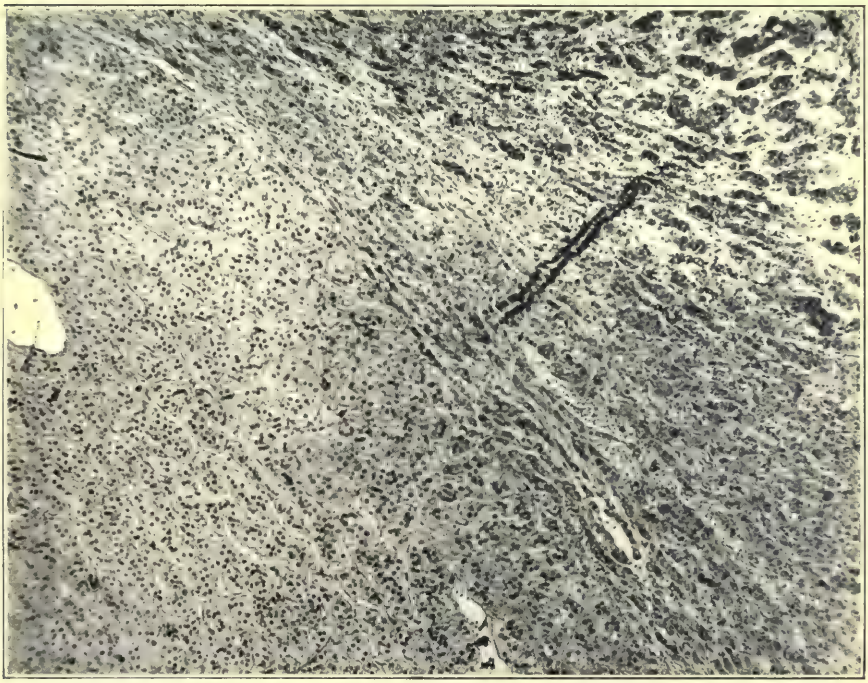


Fig. 263.—Benign tumor of the adrenal (hypernephroma), showing the tumor, the capsule, and the zona fasciculata. × 62. (Watson and Cunningham.)

If free bleeding or the passage of clots has occurred the orifice appears distended, more or less dilated, with rough and swollen edges. This is known as Fenwick's sign, but may be wanting even when abundant hemorrhage has occurred.

Diagnosis.—In a large proportion of cases the symptoms will lead to a diagnosis of renal tumor. This is especially true if cystoscopy and ureteral catheterization are not employed. With pain in the region of the kidney and moderate hematuria the picture will suggest renal tumor or calculus, in the latter case requiring radiography for differentiation. When hydronephrosis has resulted from an obstructing

growth or from hemorrhage so abundant as to produce clots obstructing the ureter, diagnisis is impossible without ureteral catheterization. An intermittent hydro- or hematonephrosis in the presence of hematuria and colicky pains is extremely suggestive of pelvic or ureteral neoplasm. Albarran and Imbert indicate the following conditions under which the diagnosis is possible: (1) Symptoms of renaltum or, a hydro- or hematonephrosis, and tumor cells in the urine are found present. Simple hydronephrosis rarely is accompanied with hematuria, but cannot be excluded unless tumor cells are discovered in the urine. The cystoscope is necessary to determine the absence of the vesical tumor obstructing the ureter. (2) Hematonephrosis without other symptoms if intermittent and if tumor cells are obtainable by means of the ureteral catheter. (3) Other symptoms being absent when the urine obtained by ureteral catheter contains tumor cells. While cylindrical or pavement cells may be found in chronic pyelitis, and suggest the presence of tumor, the absence of pus (an important sign) is indicative of tumor. (4) When the cystoscope reveals papillary tufts or a polypoid tumor projecting from the ureteral orifice, suggesting metastases from a growth higher up. Here exploration alone will determine positively whether the growth is primary in the lower ureter or an implantation metastasis.

Course and Prognosis.—It has already been stated that the course of simple papilloma is often prolonged and uneventful save for slight pain and hematuria. The tendency to malignant change must not be overlooked. Albarran and Imbert found in one case a history of hematuria attacks for a period of eleven and a half years. Operation, however, revealed a papilloma already malignant with glandular involvement, and recurrence took place six months after nephrectomy. As the disease progresses, hydronephrosis develops and in some cases infection has led to pyonephrosis with inflammatory destruction of the kidney substance. In the malignant cases, anemia, cachexia, general metastases in glands, liver, and lungs may develop. The greater pain and severe hemorrhages give the disease a more rapid course, as a rule, than the malignant renal growths.

Treatment.—With the malignant nature of these growths, the treatment of a tumor confined to the pelvis is nephrectomy. The well-known tendency of simple papilloma to recur, sometimes in a condition of marked malignancy, demands the same treatment as the frankly malignant primary tumors. Any less radical operation has proved in the past to be valueless. With tumor of the lower end of the ureter involving the intravesical portion, excision of the orifice with a margin of the vesical wall and healthy ureter, followed by implantation of the ureter into the bladder wall, is indicated. This operation can be done in either sex by the transperitoneal route, but when the disease is higher up nephro-ureterectomy should be performed. Morris recommends that in females the sacral route be employed to approach the portion of the ureter in and below the broad ligament, the kidney and

ureter being removed by the lumbo-iliac incision. In males the latter incision is sufficient for nephro-ureterectomy. Simple nephrectomy is justifiable only as a palliative for the painful symptoms in renal retention occurring in cases of inoperable tumor.

Operative Results.—Albarran and Imbert report 21 nephrectomies and 3 deaths. There were no deaths in 6 cases of papilloma operated on. Of the 18 recoveries there were 8 recurrences, 4 well after variable periods, 6 not traced. Of the recurrences 3 were in the ureter or portion remaining. The longest period for which "cure" had lasted was six years.

As the question of transplantation below the pelvis in cases of pelvic growth is always present the necessity of nephro-ureterectomy is evident. In case of a tumor involving the lower ureter requiring too extensive removal for implantation of the lower end into the bladder (ureterovesical anastomosis) the question will arise whether to perform nephrectomy, lumbar ureterostomy, nephrostomy, or Boari's operation. The latter operation consists of raising an extraperitoneal flap from the bladder wall, joining its edges, and implanting the ureter into the tube thus formed. These implantation operations have a place in which for any reason nephrectomy is contra-indicated.

SECONDARY TUMORS OF THE KIDNEY PARENCHYMA, PELVIS AND URETER.

Secondary tumors of these organs, being but a part of a general disease, are practically without surgical interest. As to their frequency compared with primary tumors, Albarran and Imbert conclude from statistics that secondary carcinoma of the kidney is more common than primary.

In 25 cases occurring in 2610 postmortem examinations at the Middlesex Hospital, the majority were carcinoma secondary to the disease in other organs, the female breast being the most common. Usually both kidneys are affected and the disease presents the same features, as regards symptomatology, as primary tumors. Morris does not mention secondary tumors of the renal pelvis. Secondary tumors of the ureter are more common than primary. Those originating in tumors of the renal parenchyma or pelvis have already been mentioned. Those secondary to malignant disease of other organs are chiefly of pathological interest.

Perirenal Tumors and Cysts.—The growths which come under this head are those arising from the fibrous or fatty capsule of the kidney, together with certain so-called retroperitoneal tumors which have an intimate relation to the kidney. They are of considerable rarity, Albarran and Imbert finding 54 tumors and 18 cysts in their collected series, not all of which can, in their opinion, be counted as undoubtedly of extrarenal origin. Gurlt found but 1 perirenal in 894 sarcomata, out of a series of 14,000 tumors of all kinds.

Etiology.—All authors are agreed as to the greater frequency in females than in males, the proportion being usually about 2 to 1. Adami found the lipomata occurring on either side with about equal frequency. Other tumors have been found somewhat more often in the right than in the left. Bilateral tumors are very rare. Children are very seldom affected, the disease being most common between the thirty-fifth and fifty-fifth years.

Pathology.—The tumors are solid and cystic, and often reach a size much greater than renal tumors. Several cases weighing 50 or 60 pounds have been reported. Histologically they are of the connective-tissue (mesoderm) class, the commonest being lipoma. Albarran and Imbert divide them into the following groups: (1) Lipoma, fibrolipoma. (2) Fibroma, fibromyoma. (3) Sarcoma. (4) Mixed tumors. (5) Cysts.

Many combinations of different tissues occur, complex growths such as fibro-myxo-lipoma arising. The "mixed" are the most rare, and, as in the renal form, may contain bone and muscle fibers. The cysts are usually of Wolffian "rest" origin, serous and blood cysts also occurring. Next to the lipomata in frequency are the sarcomata of various forms, which are the most malignant. The origin of this class of tumor is but partially understood. It is generally supposed that the "lipoma" forms may arise either from the fatty capsule of the kidney or from the retroperitoneal fatty tissue. Fibroma may arise from the renal capsule, as do the sarcomata in the majority of cases. The "mixed" tumors are doubtless of embryonic origin, similar to that of the "mixed" renal tumors already described.

In rare cases the tumor appears to develop in the tissues about the ureter. The growth may compress the kidney or surround it; practically never invading the kidney substance except in the case of sarcoma. The kidney may undergo atrophy from pressure; hydronephrosis may result from involvement of the ureter in the growth.

The tumors grow slowly, gradually filling the lumbar space, compressing the liver above if the growth is upward, the colon in front, and the pelvic organs if it extends downward. On the left, the spleen may be pushed outward and upward. As the tumor enlarges, adhesions to surrounding structures develop, less in the case of lipoma or fibroma, but sometimes to a marked degree in the sarcomata, making removal of the greatest difficulty. The cysts as a rule are not adherent. The tumors usually are encapsulated. In the more malignant forms (sarcomata and the mixed tumors) metastases may occur, most frequently in the liver and the lungs.

The lipomata are usually lobulated, the other forms may be smooth or somewhat irregular in shape. The tumors are often very vascular. The cysts may reach a large size and contain a large amount of fluid, watery or yellowish, containing albumin. Urea and uric acid have also been found present, although the adjacent kidney was normal. Softening of the tumors, from necrosis, occasionally occurs.

Symptoms.—In their earlier stages these tumors produce no symptoms and are not infrequently discovered in the course of operations for some other condition. The swelling is usually the first symptom noted, less often pain. Urinary symptoms are as a rule lacking. As the growth enlarges, the only symptoms in the benign cases are those of pressure on the neighboring structures, dyspnea, constipation, varicocele, edema of the legs, and radiating pains all having been noted. In the malignant forms the general health is more affected.

The benign tumors are of slow growth, the duration being from two to three years before operation becomes necessary, but in the sarcomata the course is shorter, averaging eight months, and the onset of pain is earlier.

Barring the absence of urinary phenomena, these growths have much the same physical signs as renal tumors. Lipomata, however, are usually quite soft and are therefore fluctuant. Morris found fluctuation in 7 out of 15 lipomata.

Diagnosis.—A tumor of large size, filling the lumbar region and flank, with no urinary symptoms and which has pushed the intestine inward, or has the colon only lying in front of it, should be suggestive of a perirenal growth. That a positive diagnosis can be made is extremely doubtful, owing to the number of conditions with which it may be confused. The diagnosis most frequently erroneously made is of ovarian tumor. If a definite history of the swelling having begun in the lumbar region and progressing downward is obtained, this should point to the perirenal origin. In ovarian tumor progressive growth from the pelvis upward and a history of menstrual disturbances should be expected. In case of suprarenal or malignant renal tumor, in which there is no hematuria, diagnosis may be impossible. Ascites, tumor of the liver, mesenteric tumors or cysts, pancreatic cysts and hydronephrosis may be sources of error but as pointed out in the section on diagnosis of renal tumors, these conditions have a somewhat different location, and a careful physical examination should, in typical cases, indicate the probable nature of the tumor.

Treatment.—Operative removal, at a stage before the tumor has reached too great a size or formed adhesions to important organs, alone offers hope of successful cure. Owing to the size of the tumor, and in case of lipomata, to the tendency of extension to or across the median line, the abdominal (transperitoneal) route is the best. In practically all cases the posterior peritoneum should be incised on the outer side of the ascending or descending colon in order to avoid injury to the vessels supplying the gut. In freeing the tumor the dangers are from excessive hemorrhage from the abundant bloodvessels often present, and from adhesions to the intestine, especially in malignant cases. The cysts are usually less adherent and easily enucleated.

As the tumor is developed the relations to the kidney and ureter must be carefully studied. If, as sometimes occurs, the growth has encased the kidney, or has reduced it to a flattened shell, nephrectomy

should be performed. On the other hand, where separation is practicable, the kidney should be left. In operating on large lipomata, it is important to observe the relations of the perirenal fascia, as pointed out by Reynolds and Wadsworth.[41] Its anterior layer lies just under the retroperitoneal fat layer, and is continuous, across the vertebral column, vena cava and aorta, with the same layer on the opposite side. Since lipomata in the perirenal space (*i. e.*, of the fatty capsule) may send offshoots across the median line, beneath this anterior layer of fascia, it is an important guide, as it offers a line of cleavage around the growth, and separates the tumor from the colon, small intestine and pancreas. In these extensively spreading tumors care must be taken not to injure the mesenteric arteries, and also the spermatic and ovarian which, near their origin, traverse the perirenal space.

Where the growth is extensive and becomes a bilateral affair, an incision should be made on the other side. Lobulated growths as lipoma and fibroma may be removed piecemeal.

The operation may be of great difficulty and accidents are not rare, death on the operating table having occurred from hemorrhage or later from perforation of adherent intestine. The former high rate of operative mortality has of recent years been reduced by improved technic. Albarran and Imbert in a series of 45 tumors, found 27 cures, 12 deaths and 5 not traced. Adami[2] records 46 per cent. of successes in 26 operations for lipomata.

Prognosis for cure, although recurrence of lipomata occasionally occurs, is usually good in case of benign tumors. In the malignant cases there is a strong probability of recurrence, very few cures having been reported. Albarran and Imbert mention a case of sarcoma in a child, aged seven years, which was free from recurrence five years after operation.

CYSTIC TUMORS OF THE KIDNEY.

Classification.—It has been customary with writers on surgical diseases of the kidneys to group together the various forms of cystic disease of neoplastic nature. Albarran and Imbert, following this plan, divide them into the following groups:

(*a*) Cysts of nephritis; (*b*) serous cysts, uni- or paucilocular; (*c*) polycystic kidney; (*d*) hydatid cysts; (*e*) dermoid cysts.

The cysts of nephritis, included doubtless for the sake of completeness, are of no surgical interest. They are minute, multiple retention cysts, found in chronic interstitial nephritis, and present no symptoms *per se.* They therefore do not demand further attention here. Owing to the wholly different origin of hydatid cysts, these will be discussed in a separate chapter on Echinococcus of the Kidney. Dermoid cysts, owing to their close relationship with teratoma, have been included under that heading. There remain, therefore, two forms of

cystic disease to be considered here. In order of their importance they are:

(*a*) Polycystic kidney.

(*b*) Solitary or simple cysts.

The latter group is subdivided into (1) serous cysts and (2) hemorrhagic cysts.

The relative frequency of polycystic kidney and serous cysts is shown by Albarran and Imbert's figures, who collected 53 cases of polycystic disease and 27 of serous cysts. The hemorrhagic type is more rare. In the writer's collected series for five years previous to 1915, the number of cases was as follows: Polycystic kidney 36; solitary cysts 8; hemorrhagic 1. Brin[9] found but 11 cases of the latter in the literature.

Polycystic Kidney.—**Etiology.**—*Age.*—The disease may develop at any age, from birth to the eightieth year or later, but there is a striking freedom between infancy and adolescence. In the writer's collected series of 36 cases, but 5 were under twenty years, 10 were between twenty and forty years; over forty years, 16 cases. The greatest incidence is between the fortieth and sixtieth years, Seiber finding 107 out of 173 cases, in these decades. The fact that in infants the majority of cases are found in the first few months of life has led to a separate classification for "congenital" and "adult" forms of the disease.

Sex.—The majority of authors state that the disease is more common in females than in males. In the writer's collected series there were 20 females and 12 males (4 sex not stated).

Side Affected.—The disease is, as a rule, bilateral, although one kidney is usually found more extensively affected. In 149 cases Seiber found but 9 cases of unilateral disease, of which 6 were on the left, 3 on the right side. The unilateral ones appear to be more common on the left.

Heredity.—There appears to be a marked predisposition for the disease to appear in families, a number of instances of this having been reported, rarely, however, in more than one generation. Osler[37] refers to the case of a mother who gave birth to five children affected with the disease. Paus[38] quotes Bull's cases which occurred in three generations. This appears to be exceptional.

Pathological Anatomy.—*Gross Appearance.*—The disease consists of multiple cysts scattered more or less throughout the kidney and immediately beneath the capsule. The enlargement of the organ varies according to the number and size of the cysts, which may be microscopic or of several centimeters in diameter. The tumor preserves the normal kidney shape fairly closely but the surface is rough and irregular owing to the superficial cysts which give it a knobby appearance. In the majority of cases the kidney is enlarged to two or three times its normal size, but it may be much larger. Morris refers to a case in which the tumor was fifteen and one-quarter inches in length and weighed fifteen pounds. The cysts are closely packed together and

tend to develop toward the anterior surface of the kidney so that the hilum is pushed backward. In color the tumor is variegated, grayish, reddish or light yellow or brown, due to the thin cyst walls whose translucency reveals the color of the contained fluid, which is thin and transparent or turbid, viscid or colloid. It may be urinous, and contain uric and hippuric acid, calcic oxalate, leucin, cystin and tyrosin; in the larger cysts the fluid may be of a serous character, and albuminous with more or less blood, fat and cholesterin in varying quantities. The cysts may be separated by fibrous tissue or by renal parenchyma which has undergone pressure atrophy and interstitial nephritis, especially in the region of the larger cysts. Where less compressed, the parenchyma may be practically normal. Suppuration in some parts of the tumor is not rare. Dilatation of the pelvis sometimes occurs from displacement of the organ and consequent kinking of the upper end of the ureter. Occasionally fibrous degeneration about the hilum transforms this part of the tumor into a fibrous mass. As the tumor enlarges it pushes the large intestine in front of it.

As mentioned above the disease is usually bilateral, but the process is almost invariably further advanced in one than in the other kidney.

Microscopic examination shows a thin cyst wall, lined with epithelial cells, cylindrical or flattened and cuboidal in shape (Fig. 262). In places the epithelium appears to have undergone proliferation, sometimes forming papillary buds projecting into the cavity. Large numbers of epithelial cells are often seen in the contained fluid. The outer surface of the cyst is in contact with the renal parenchyma, which varies from a normal to a condition of marked atrophy and fibrous change. The fibrous tissue varies in density and is sometimes hyaline. The tubules and Malpighian corpuscles show all stages of changes, from slight dilatation to actual cyst formation. The cysts do not communicate with the pelvis or calyces but often with each other. The arteries in the parenchyma often show changes of endo- and perivascular inflammation. Foci of leukocytic infiltration may be seen, and the occurrence of abscesses has been mentioned. This may be seen at times in the perirenal tissue.

Associated Lesions.—The occurrence of lesions in other organs is striking, which may be secondary to the renal disease or congenital malformations. Hypertrophy of the heart is not infrequent, the left ventricle being especially affected. Arteriosclerosis occurs in 75 per cent. of the cases (Garceau). In adults, cyst formation in the liver has been frequently noted, Seiber[44] finding it present 39 times in 212 cases. This rarely is found in infants. In Still's series of 35 cases only 3 were in infants. Of the congenital lesions, a large variety of malformations have been recorded, often several lesions occurring in the same case. Garceau quotes a case in which double cystic kidney, meningocele and supernumerary digits and toes were present. Morris refers to cases in which talipes, cleft-palate, and imperforate anus; and (in one case) absence of rectum, urethra and external genitals were

PLATE VIII

Polycystic Kidney.

(From Surg. Path. Museum, Harvard Medical School.)

found. Congenital stricture of the urethra with bilateral hydronephrosis were seen in another case.

A rare condition is cystic disease of other organs than the liver. Sieber noted cysts of the ovaries in 6 cases; of the choroid plexus in 3; of the epididymis in 1.

Pathogenesis.—In the pathogenesis of polycystic kidney the fact is clear that the cyst formation is due to occlusion of the urinary tubules. In some cases the occlusion is close to the glomeruli, while in others it may be in the more or less remote portions of the convoluted tubules. The fact that in certain forms of the affection the cyst is found in the cortex is evidence, in adults at least, that the process is largely in the convoluted tubules. The fundamental cause of the occlusion is still shrouded in darkness and as a result there is a wide diversity of opinion among writers on the subject; much speculation and discussion has arisen, and many theories have been propounded.

The occurrence of the disease in the newborn and in infancy and again in later life, the intervening years being almost entirely spared, suggests that the cause may be different for the congenital from that which is responsible for the disease in adults. In consequence certain authors have been led to believe that the two diseases are of different nature, while others hold that the cause is the same and have explained the adult condition by assuming that the disease is always congenital but has remained latent until, for some obscure reason, the process of cyst formation becomes active. Other writers have advanced the theory of newgrowth, of interstitial inflammation causing compression of the tubules, and finally there are those who attempt to explain the condition on a combination of these theories.

It may be of interest to review more in detail theories of the best-known authorities. One of the earliest theories was that of Virchow, who believed that the congenital form was due to a fetal inflammation involving the papillæ with resulting obstruction of the tubules. Later observers have not confirmed this theory, and attempts to produce this result experimentally by causing inflammation of the papillæ have failed, the dilatation of the tubules being but temporary and no cyst formation taking place. Malassez noted the occurrence of cyst formation elsewhere in the body and was led to believe the process to be of the same nature as cystadenoma of the testicles and other organs.

Brigidi and Severi thought the process to arise by epithelial proliferation in the tubules, due to irritation, followed by degeneration which resulted in the cysts. They considered it analogous to the process of cystoma of the ovary. The newgrowth theory was further developed by Nauwerch and Hufschmid who called attention to the papillary formation of the cysts. These they believed to be tubular proliferation, the cysts themselves being due to degeneration, evidenced by the masses of colloid material found in them. Ritchie came to the conclusion that the process is different in the newborn from that in the adult form; the former he believed to be malformation, the latter an

irritative lesion leading to proliferation of the epithelium of the tubules and Malpighian corpuscles and to connective-tissue changes, and that the disease is similar in character and origin to cystic liver. Von Kahlden held the view that the process was neoplastic both in the adult and in infancy. Albarran and Imbert held a similar opinion. The presence of congenital cystic liver and the various fetal anomalies mentioned above have been regarded by Moscowitz, Berner and others as strongly supporting the theory of malformation. Recent studies in the embryology of the kidneys lend color to the belief that the disease is due to defects in development.

The developmental process as now understood by modern embryologists upon which the various "malformation" theories of the origin of polycystic kidney are based, may be described as follows: The kidney as a whole is formed of two embryonic structures, the cortex and greater part of the medulla arising from nephrogenic tissue of the Wolffian body, while the ureter, pelvis, and a portion of the medulla, containing the collecting tubules, are a separate formation from the Wolffian duct. Normally these two parts unite, and the connection becomes established between the former (renal) portion, containing the glomeruli, convoluted tubules and Henle's loops, and the latter (pelvic) portion, containing the collecting tubules. Thus the urinary channels become continuous from glomeruli to calyces and pelvis. The "malformation" theory is based on the assumption that there is a failure, more or less general, on the part of these two portions to unite, and an obstruction results affecting the tubules of the medullary portion, and causing the cystic dilatation of the tubular system above the collecting tubules. As stated by Lund,[32] "The extent of the process will depend on the relative number of the tubules that fail to meet. If a large proportion fail to connect, then the cystic formation will be rapid and complete, and, no kidney tissue being left to eliminate urine the patient will die. If, on the other hand, there be left comparatively large areas of healthy kidney tissue, enough for the elimination of uric acid, the patient will live for years and die from other causes. The presence of the increasing cystic tissue may finally so squeeze the intervening kidney tissue as to cause insufficiency and the patient dies from this."

The frequent occurrence of malformations elsewhere in the urinary tract, associated with polycystic kidney has already been mentioned. In this connection a case studied by Hornowiski[18] is of interest. In an infant dying a few hours after birth without having secreted urine, autopsy showed the bladder empty, and complete atresia of the left ureteral orifice. The kidneys were normal in appearance, but on section dilated tubules and an occasional cyst were found. Near the papillæ were seen streaks of connective tissue without dilated tubules. Injection with lithium carmine near the cortex showed that the fluid passed freely through the dilated tubules *toward*, but *not reaching* the pelvis. Microscopic examination of the connective-tissue barrier

showed it to be of embryonic character with no signs of inflammation. The glomeruli were normal. He concludes that the process is an error in development. A case mentioned by Letulle and Verliac[29] lends support to this theory. In this the kidney was in a condition of congenital aplasia, and the remaining portion showed congenital cysts. Berner[5] studied 28 cases in serial sections, and found no evidence of inflammatory origin, but isolated glomeruli and blind tubules which he considered developmental defects. The epithelial proliferation (papillary formation) he interpreted as a natural attempt at regeneration (compensatory hypertrophy). A similar view is held by D'Agata.[13] The presence of occasional cartilage and smooth muscle tissue in polycystic kidney is explained by them and other authors as another development defect associated with the cystic disease.

In summing up the various theories for pathogenesis it may be said that for the congenital form of the disease the theory of malformation seems to have the strongest support. The various theories of inflammatory origin have been found to lack sufficient evidence, and the papillary formation, upon which the theory of newgrowth has been based, is explained as being a process of compensatory hypertrophy. That in the adult form of the disease there is some congenital malformation which remains latent until past middle life, as a rule, seems probable. Whether or not the disease in the adult is precipitated by some toxic influence giving rise to an interstitial inflammation in the kidney has not as yet been proved.

Symptoms.—The symptoms of chief importance in polycystic kidney are tumor, pain and signs of renal insufficiency. Owing to the fact that these may not occur together, but one may precede the others by a considerable period, the clinical history is usually divided into three stages:

1. The stage of progressive enlargement of one or both kidneys without other symptoms. The renal tumor is discovered by accident, if at all, and the disease is usually latent in this stage, which may last from a few months to several years.

2. In the second stage the tumor may be more or less easily demonstrable and subjective symptoms appear. These are local pain and tenderness, the former often of a dull aching character in the lumbar region, occasionally in the abdomen; this is usually on one side at first but becomes bilateral if the disease progresses sufficiently in the second kidney. The pain at first is paroxysmal, later becoming continuous in some cases, usually made worse by exercise. The patient is often relieved of the pain when recumbent. If hematuria occurs with passage of clots through the ureter, colicky pains are felt. If the kidney becomes mobile there is danger of ureteral obstruction and hydronephrosis, in which case pain may be unusually severe. Exceptionally, pain is wanting until very late in the disease. Other symptoms in the second stage are those due to beginning renal insufficiency, such as headache, vomiting, flatulence and constipation. Frequency of

micturition occurs in some cases. Urinary changes seen in the second stage are usually those of mild interstitial nephritis, the quantity being slightly increased as a rule, the specific gravity falling below 1010, and slight traces of albumin and casts appear, usually toward the end of this stage. Albumin, however, may be entirely absent unless there is hematuria. The urine reaction is generally acid. The amount of urea excreted is usually normal until the third stage approaches.

3. In the third stage the symptoms are those of uremia, such as violent headache, drowsiness, convulsions and coma, which may be accompanied by severe dyspnea. This stage is naturally of short duration. The patient becomes wasted and cachectic; at times a bronzing of the skin appears not unlike that seen in lesion of the suprarenal capsule. (Morris, Garceau.) Late in the disease fever of a hectic type, ascites or edema may develop; the edema is usually caused by pressure of the enlarging tumor. When suppuration takes place, as may occur in the later stages, increased tenderness and pain, usually accompanied with fever, are noted. In rare cases, severe hematuria has been the only symptom noted. The secondary complications of interstitial nephritis, such as cardiac hypertrophy and signs of general arteriosclerosis when present, occur late in the second stage, but sudden cerebral hemorrhage has been known to occur before other signs of the disease have become prominent, and other hemorrhagic symptoms, as petechiæ, bleeding from the nose or bowel, have been reported.

According to Garceau another not uncommon complication is the development of tuberculosis in the polycystic kidney.

The *duration* of the disease may be difficult to estimate in any given case, as sometimes symptoms are late in appearing and the active course lasts but a few months. On the other hand, cases are reported the duration of which were ten or even twenty years. As a rule, however, the course of the disease is not more than five or six years. Where the disease exists at birth, the renal enlargement may have been sufficient to cause difficulty in delivery and premature labor is not uncommon. According to Boinet and Rabaud,[7] death occurs immediately after birth in 50 per cent. of the cases. If the child survives, besides the large abdominal tumor, symptoms of pulmonary embarrassment, dyspnea and general wasting are noted, convulsions and coma usually preceding death.

Physical examination reveals a tumor of one side only in the majority of cases. As above stated the tumor may be overlooked. In an analysis of 88 cases Ritchie[42] found tumor present during life in 21, of these the tumor was bilateral in 8 cases only. In the writer's collected series of 36 cases occurring in the years 1909–1914, tumor was present in 20, 8 of which were on the right side, 11 on the left and 1 bilateral.

The tumor causes a dull note in the region of the kidney or below it, but in some cases the enlargement is toward the epigastrium. The intestine, as the growth enlarges may be pushed forward or to the inner side, as with malignant tumors of the kidney. In thin subjects

the irregular surface of the tumor, due to the cysts, may be felt, or the tumor may appear smooth. A considerable degree of mobility may be present, and forcible dislodgment of the tumor may cause pain of a sickening character. The tumor may be hard or of a somewhat soft consistency; definite fluctuation is not common. It may be large enough to cause bulging in the flank, or even to nearly fill the abdominal cavity.

Cystoscopic Evidence.—In the presence of hematuria the source of blood may be determined by this means, otherwise this procedure is of little value in diagnosis. The evidence obtained by ureteral catheterization may be of little value since the quantity of urine secreted by the more diseased kidney may be greater or less than that from the other kidney. The phenolsulphonepthalein test, however, will be of some prognostic value when operation is considered.

Diagnosis.—The insidious nature of the disease makes the diagnosis in some instances of great difficulty or even impossible. In Lejar's series of 62 cases the correct diagnosis was made during life in only 5. In 68 cases studied by Ritchie the disease was first discovered at autopsy in 7, there having been no symptoms referable to the kidneys. The cases in which uremic symptoms suddenly appear without the discovery of the tumor, or where the evidence is of a chronic nephritis, are most misleading. In typical cases, the tumor formation, pain and nephritic symptoms should indicate the nature of the disease, particularly if its bilateral character can be demonstrated.

Where unilateral, the presence of a large tumor only suggests malignant tumor, but usually the absence of severe cachexia or hemorrhage point to polycystic disease. The cardiac and arterial changes are important when present. Hydronephrosis, pyonephrosis, simple and hydatid cysts are conditions likely to be confused. Hydronephrosis may be differentiated by its more intermittent character, and the entire subsidence of the tumor, sometimes sudden, and accompanied by the passing of a large amount of urine, or by emptying the cyst with the ureteral catheter. The latter means should avail also in pyonephrosis (besides the large amount of pus in most cases). Simple cysts are usually unilateral and do not cause the symptoms of nephritis or cachexia seen in polycystic disease. The urine also is likely to be negative. In hydatid disease the process also is commonly unilateral, and the presence of hooklets in the urine establishes the diagnosis.

Course and Prognosis.—Rapidly fatal in the newborn, of fairly brief duration in infants, the disease in the adult is of slow evolution. During the first stage the disease is latent in most cases, and the patient is in apparently good health. An unexpected attack of uremia, pneumonia or pulmonary edema, cerebral hemorrhage, convulsions, coma or anuria may be rapidly fatal. According to Morris rupture of the left ventricle may occur. Hematuria, if severe and prolonged, may bring on fatal exhaustion.

In other cases the period of active symptoms may be prolonged

for years, sometimes with intermissions of relatively good health. If one kidney only is affected, life may be prolonged for years to be terminated by exhaustion from pain, hematuria or other hemorrhages or intestinal disturbances due to pressure from the enlarging tumor.

If bilateral, the duration of life depends on the rate of development of the cysts and on the consequent damage to the renal parenchyma. Ritchie found of 28 cases, 15 died between the first and tenth years, the others living from a few months to twenty-two years. In the last stages, when the approach of death is gradual, obstinate vomiting, convulsions, suppression of urine and coma are the terminal symptoms.

The prognosis in operated cases will be discussed under Treatment.

Treatment.—With the large proportion of cases in which the condition is bilateral and with the difficulty which exists in cases apparently unilateral of determining the certain absence of the disease in an early stage in the second kidney, the treatment in theory at least would naturally be conservative. Such a radical measure as nephrectomy of the diseased kidney for the above reasons would incur too much risk of failure through the presence or development of cysts in the remaining kidney. Practically, however, it has been found that nephrectomy can be successfully done, insofar as the relief of present symptoms is concerned and ensuring to the patient reasonably good health for an indefinite number of years. A radical operation should of course not be considered under these circumstances unless threatening symptoms make it imperative. There remains, therefore, a large class of cases in which some form of palliative treatment only is indicated. The various procedures may be classified as follows:

Palliative Treatment:

1. Non-operative:
    (1) Medical Treatment of the Nephritis.
    (2) Lavage of the Kidney by Ureteral Catheter for Hematuria.

Operative:

1. Nephropexy.
2. Decortication.
3. Puncture of the Cysts. (Rovsing's Operation.)

Radical Treatment:

1. Partial Nephrectomy.
2. Total Nephrectomy.

Palliative Treatment.—In the milder forms of the disease when bilateral or when conditions exist such as pregnancy, which preclude any more radical measures, the ordinary dietary and hygienic therapeusis, such as is employed in chronic nephritis, is indicated. The avoidance of an excess of proteids and alcohol in the diet are of the greatest importance.

Pelvic Lavage.—This has been employed in a few cases of bilateral disease accompanied with hematuria with the result of temporarily arresting the hemorrhage. It has no curative effect and can only be

regarded as indicated in a small proportion of cases not amenable to more radical measures.

OPERATIVE TREATMENT.—In cases of polycystic disease in the first stage or early in the second stage where the symptoms are due to a heavy mobile kidney, causing dragging pain, or attacks of hydronephrosis by kinking of the ureter, fixation of the kidney alone has in some cases given relief. This relief may be of several years' duration, according to the rapidity with which the disease progresses. It is at best an uncertain form of treatment as regards prolongation of life. This operation has been combined with the treatment of a hydronephrotic sac where indicated.

Nephropexy.—Nephropexy as a step in a more radical operation is always to be employed if the kidney has any considerable mobility.

Decortication.—This procedure also has a limited application and would only be employed where threatening symptoms of renal insufficiency were present and the patient's condition contra-indicated any more thorough operation. It would seem to be less effective than puncture of the cysts, which in most cases improves the renal function by the liberation of the compressed parenchyma, and adds little to the severity of the operation.

Puncture of the Cysts (Rovsing's Operation).—Although performed in a somewhat experimental and incomplete manner by Curtis and Kammerer,[12] Lund,[32] Witherspoon,[55] and others with satisfactory results, this operation was fully developed and elaborated by Rovsing.[43] As this operation has a low mortality and is a more effective means of removing pressure of the cysts from the active renal parenchyma, it would seem to deserve the most prominent place in surgical treatment. It not only relieves the compression of the kidney tissue but, by checking further development of the larger cysts which are exerting pressure, it will, theoretically at least, prevent to some degree the increasing obstruction which is responsible for further development of the minute cysts that are present in large numbers.

The technic of Rovsing's operation consists in exposing the kidney through the oblique lumbar incision and puncturing the cysts on the anterior and posterior surfaces and external border so far as a wide retraction of the wound allows. As this empties the tumor of a large amount of its fluid contents, the kidney is diminished in size, so that delivery through the wound is finally accomplished. Then the remaining superficial cysts may be punctured and the deeper cysts, felt by palpation, may be emptied by an aspirating needle or trocar. Care should be taken to avoid areas of normal kidney tissue wherever they can be seen or felt, in order to preserve the parenchyma and to avoid bleeding. According to Lund, a kidney as large as 6, 8 or even 10 times normal size, may, by this means, be reduced to something approaching twice the normal. The kidney is then replaced, fixed if necessary and the wound closed as a rule with drainage. The operation should be performed on one kidney only at a time. In one case Lund found it

necessary to repeat the operation a second time in an interval of nine months. Six months later the patient was reported in good condition. The striking immediate results are the relief of pain and the restoration of kidney function, evidenced chiefly by the increase in the quantity of urine. Cases in which the operation was performed were 3 by Rovsing, 4 by Lund,[33] and was reported as well one year later in one case, 5 were reported well from six months to three years after operation, and the sixth case was too recent to state the final result.

Radical Treatment.—*Partial Nephrectomy.*—This operation must necessarily be of distinctly limited application. In a case where the kidney being exposed and the cyst found limited to one pole only of the kidney, the second having been proved to be normal or but slightly affected, partial nephrectomy is justifiable. Tuffier performed this operation resecting the inferior half of one kidney and the patient was well two years after operation. The objection to this procedure is the uncertainty of checking the disease from further development in the affected kidney tissue remaining, on both sides, and should contra-indicate it in most cases.

Nephrectomy.—Owing to the large proportion of cases in which the disease is bilateral as mentioned above, nephrectomy is the operation of last choice as a rule. Exceptional cases, however, exist where owing to hemorrhage, suppuration or pain of a severe and threatening degree it has been performed, and a sufficient number of successful cases have been reported as to warrant its use here as a means of prolonging life. It is of course contra-indicated in the presence of large bilateral tumors where the removal of one kidney would be only to precipitate a fatal uremia or anuria by the advance of the disease in the remaining kidney. Where operation is contemplated the abdominal route should be employed in order that the second kidney may be palpated and the existence of the disease in it noted. Where pus is suspected, however, the bilateral lumbar incisions are preferable. The healthy or less diseased kidney being explored first, then if the disease is found to be far advanced on this side the more diseased kidney is attacked conservatively through the loin. Incisions for nephrectomy in this disease are those already discussed under Treatment of Malignant Renal Tumors (p. 629).

Morris, reports 5 cases in which nephrectomy was performed, 2 cases were well three and seven years after operation, respectively, 2 cases died within a few days, one lived a few weeks following operation. Torrance[49] reported a patient well two years after nephrectomy, the remaining kidney being found healthy at operation. Albarran and Imbert found 25 operative recoveries in 34 cases, in 15 of which the patient survived from several weeks to seven years. Six had probable recurrence in the remaining kidney from two to three years after operation. In Seiber's 62 cases the operative mortality was nearly 33 per cent., and there was rapid recurrence in 10 cases, the remainder being well from eight months to seven years after operation.

Nephrectomy should therefore only be considered in unilateral cases or with very slight degree of cystic degeneration in the second kidney, and in the presence of severe and threatening symptoms. The results are much less encouraging than those reported in cases of Rovsing's operation.

SIMPLE OR SOLITARY CYSTS.

This disease has been variously termed as simple, serous or hemorrhagic cysts, large serous cysts, and in contradistinction to polycystic kidney is represented by one or a comparatively small number of cystic cavities containing serum, blood or a mixture of the two. The condition is rare, Brin[9] finding but 53 cases of large serous cyst in the literature. Israel found 1 case in 297 cases of surgical disease of the kidneys.

The condition must not be confused with the small retention cysts found in interstitial nephritis, which have already been referred to, nor, on the other hand, with hydronephrosis. Albarran and Imbert collected 31 cases from the literature, 4 of which were bilateral. Garceau, on the other hand, states that simple cysts are essentially unilateral; in this respect differing radically from the polycystic disease. In the writer's collected series from 1909–1914 there were 8 cases of unilateral cysts.

Etiology.—The disease is found almost invariably in adults, often in those of advanced years. Fowler, in 34 cases, found the ages ranging from four to seventy years, the majority being over forty years old. Albarran and Imbert found the average age in 21 cases to be forty-six years. They found the extremes to be sixteen months (the case of Kosinsky), and seventy-seven years. The majority of authors agree on the somewhat greater degree of frequency of the disease in women than in men. In the writer's collected series there were 4 of each sex. Brin found the right kidney affected more often than the left; and Fowler 22 cases of the right, 10 of the left and 1 bilateral. Albarran and Imbert are of the opinion that the proportion of the bilateral cases is larger than statistics show; this they explain on the supposition that a smaller cyst exists in the other kidney and its discovery is not possible.

As to the portion of the kidney affected, Brin found the cyst in the upper pole in 12 cases, in the lower pole 23, on the convex border twice and on the anterior surface twice.

Pathology.—*Serous Cysts.*—The typical form is a thin-walled, translucent, elastic cyst projecting above the surface of the kidney, and in the larger recorded cases the sac has reached the size of a child's head. In the case reported by Morris the cyst filled the abdominal cavity and the contents weighed sixteen pounds. Cysts are also found of minute dimensions, the smallest ones only at autopsy. Those discovered clinically are usually at least as large as an orange. Morris states that probably less than one-fourth reach a size large enough to attract attention during life. The color may be pale or yellowish

according to the character of the contained fluid. Frequently simple cysts may be multiple, consisting of a large and a few smaller ones.

The disease is usually in the renal cortex, less often the cyst seems to arise in the parenchyma and may reach the pelvis, but as a rule does not open into it. When situated on the surface the greater part of the cyst projects beyond the renal outline, but on the kidney aspect the kidney tissue is depressed to form a cup-shaped cavity.

Microscopic examination of the cyst wall shows it to consist of fibrous tissue of moderate thickness, the cavity being lined with more or less flattened cubical epithelium, and smooth throughout. On the renal aspect of the cyst, the kidney tissue may be more or less atrophied from pressure by the cyst, the epithelial lining of which is in contact with the renal tissue. Elsewhere the cyst wall may in places be semi-cartilaginous or impregnated with salts; bloodvessels are seen on the surface.

Contents.—The cyst contains a clear fluid, colorless or yellowish containing albumin and salts, rarely traces of urea. Colloid material or cholesterin have been found where hemorrhages have occurred.

Hemorrhagic Cysts.—This condition is essentially the same as simple, serous cyst but has sometimes been classified as a distinct type. In all probability it represents the serous cyst into which bleeding has occurred. In support of this theory is the fact that intermediate forms are sometimes found, the contents being slightly blood-stained serum or serum containing old blood clot.

In both varieties the characteristic point is the impossibility of separation of the cyst from the underlying kidney tissue. In its distal portion the cyst may be adherent to the surrounding tissues or organs; if in the upper pole, to the diaphragm; if in the lower, to the intestine. This possibility of adhesions is the chief cause of difficulty in their removal.

Pathogenesis.—The theories which have been adduced to explain the origin of this condition are: (1) Congenital malformation. (2) Retention due to interstitial nephritis. They must be regarded as wholly unsettled since no evidence is forthcoming as to the nature of the origin of the cysts. Moreover, the question of whether they arise from tubules or the Malpighian corpuscles is likewise shrouded in mystery.

The possibility that in some way the disease may be akin to polycystic kidney is suggested by Albarran and Imbert who have noted bilateral serous cysts and also the condition of simple cyst in one kidney with polycystic disease in the other. The evidence, however, in support of this theory is so meager that it cannot be regarded as more than suggestive.

Symptoms.—Inasmuch as in many cases the cysts are of small size, and as they rarely interfere with the function of the kidneys, even when of considerable size, symptoms are, as a rule, slight or wanting. Only when the cyst becomes of such size as to exert pressure on neighboring

structures are symptoms evoked. Until the cyst has reached a size large enough to produce a palpable tumor, pain will rarely be noted, but as the cyst enlarges it may appear, at first of a dull dragging and aching character, in the loin or the hyperchondrium, and made worse by exertion. Gradually, interference with digestion and weakness may develop, and, where the cyst has become of great size, emaciation, debility and prostration. Urinary symptoms are as a rule absent, although rarely hematuria, possibly due to trauma, has occurred. Garceau mentions a case in which there were marked urinary symptoms. The tumor when present may be distinctly elastic or firm; if posterior to the kidney the latter may appear as a movable kidney with hydronephrosis. A large fluctuating cyst growing from the lower pole has in women led to a diagnosis of ovarian cyst.

Diagnosis.—The smaller serous cysts are discovered accidentally at operation or autopsy; the larger ones are more easily confused with hydronephrosis and ovarian cysts. The points of differentiation of these conditions have already been mentioned. Hydatid cysts may be confused but usually afford evidence in the urine, and are attended by spasmodic pain when they rupture. Ureteral catheterization will be of no value save to exclude the presence of hydronephrosis.

Prognosis is that of wholly benign growth until the cyst has reached such dimensions as to produce pressure effects.

Treatment.—The simple procedure of puncturing, formerly employed but now condemned on account of its temporary affect and danger of injury to important viscera, needs no further mention. The treatment therefore consists of operative procedures for the complete removal of the cyst or destruction of its secreting membranes. The following procedures will be considered in order:

1. Incision and suture through the skin (marsupialization). In this operation the cyst is opened and drained and the edges of the incised cyst sutured into the wound. This is an unsatisfactory procedure owing to the danger that an intractable fistula will result, as occurred in 2 cases out of 6 reported by Tuffier. A modification has been suggested in cauterization of the cyst lining with carbolic acid or other agents, with or without partial removal of the cyst wall before suturing, but this cannot be regarded as desirable except in cases where a more radical operation is contra-indicated.

2. *Nephrectomy.*—This has been employed in a fair proportion of cases but is not without its serious dangers. In case that the kidney on the affected side retains its normal function and in consequence the remaining kidney has not become hypertrophied, nephrectomy is here accompanied with the danger of uremia, from the sudden strain being thrown on the healthy kidney. On the other hand, Albarran and Imbert record 7 successful cases. Where the cyst is situated as to involve the renal vessels, nephrectomy may be far safer than an attempt to separate them from the cyst wall. In rare cases where the kidney substance has been largely destroyed, nephrectomy is to be

preferred. In any case the condition of the patient may be a determining factor.

3. *Resection.*—Removal of the cyst with the underlying kidney tissue as first suggested by Tuffier is the operation of election. The route to be chosen must depend upon the size and position of the tumor, while as a rule the smaller cyst may be attacked retroperitoneally through the lumbar incision. The larger cyst may be better approached by the transverse or pararectal abdominal incision. On exposing the cyst by the lumbar route the tumor is developed, care being taken not to injure the peritoneum and adjacent structures. In doing this it may be desirable to evacuate the cyst at once. On reaching the kidney, inasmuch as separating the wall from the adjacent kidney tissue is not possible, the underlying kidney tissue must be excised, usually in the form of a wedge-shaped portion of the kidney parenchyma. (See Plates IX and X). The cyst and kidney segment being removed, the wound and kidney are closed by through-and-through catgut sutures.

Results of Operation.—Brin[9] found, in 12 cases treated by transperitoneal nephrectomy, 2 deaths from peritonitis, while in 6 cases of lumbar nephrectomy there was no operative mortality. Albarran and Imbert report 5 cases of partial nephrectomy with recovery.

TUMORS OF THE ADRENAL GLAND.

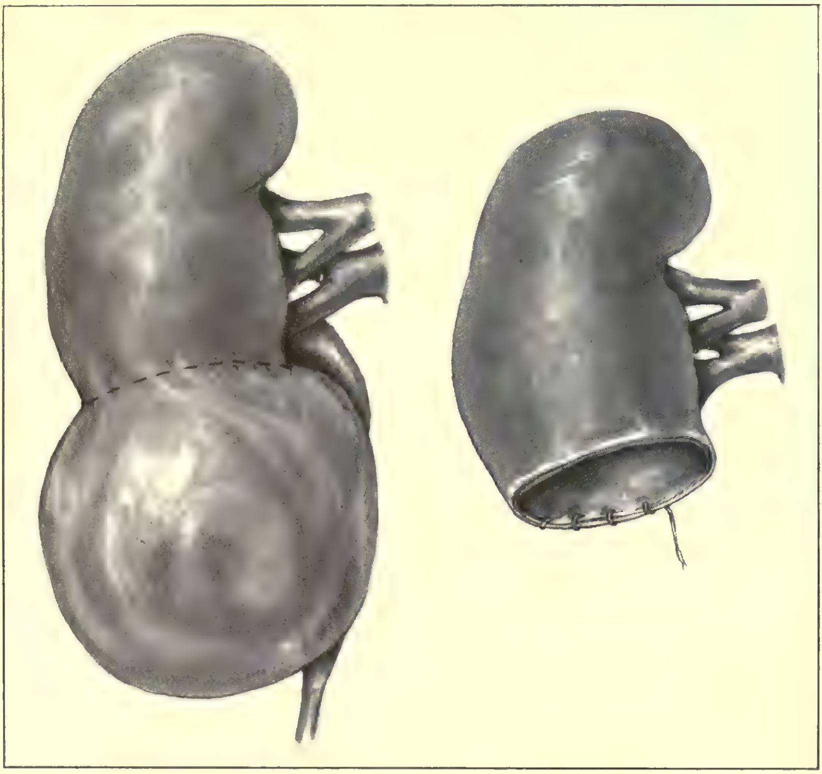
Inasmuch as the treatment of this disease is surgical and the operation in most cases involves the kidney it seems proper to include in this chapter tumors of the adrenal gland.

Etiology.—The tumors of the adrenal gland are of much greater rarity than the so-called adrenal tumors of the kidney. As to their frequency few statistics are available. Williams[52] found but one in a series of 8000 cases of tumors affecting various parts of the body. Another peculiarity is their relatively frequent occurrence in children. In the writer's collected series for the years 1910 to 1915, but 5 cases appeared in the literature, 2 of which occurred in children. Williams collected 36 cases; in over one-half of which the subject was a child. Ramsay,[40] collected 67 cases of which 36 occurred in the male, 26 in the female and in 5 the sex was not stated. Of the 6 cases in the writer's list, 3 were males and 3 females. There appears no great difference in the liability of the two sexes to this disease.

Pathological Anatomy.—Adrenal tumors are of benign or malignant character, and are therefore described under these headings. There are also cases of the so-called hypernephroma, the benign nature of which is disputed, but for purposes of description these will be considered as belonging to the malignant group.

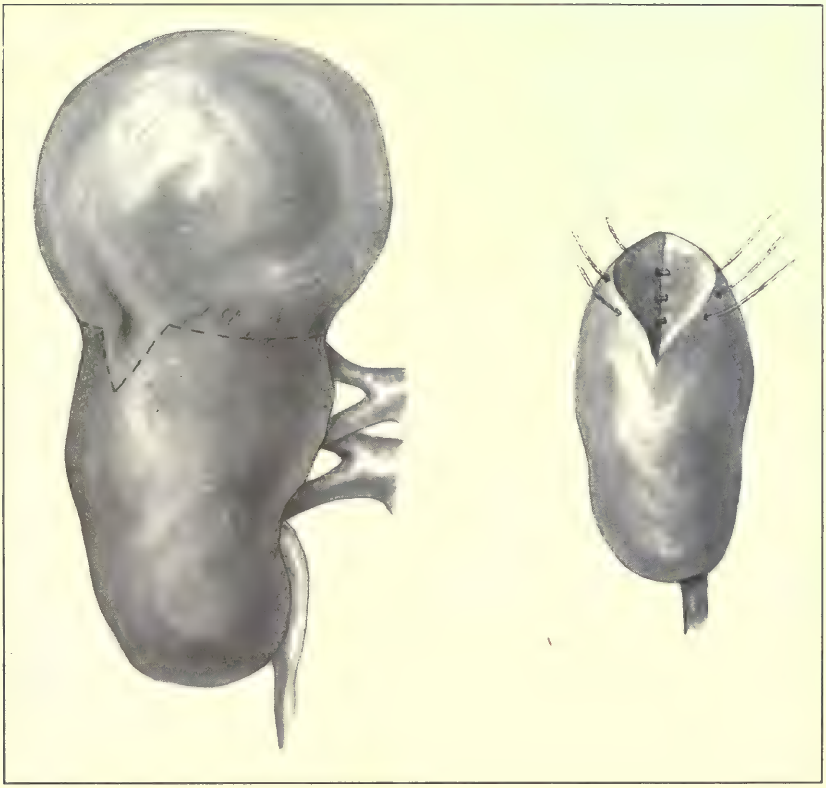
Benign Tumors.—These are rare and of considerable variety. Garceau, in a thorough study of the literature, found cases reported as angioma, glioma, neuroma, gangliofibroma, lymphangioma, ganglio-fibroneuroma, lipoma, cysts and hypernephroma. Angioma appears

PLATE IX



Partial Excision of Simple Cyst of Kidney. (Brin.)

PLATE X



Resection of Simple Cyst of Kidney. (Brin.)

as a solid mass, bright red in color, which the microscope shows to be formed of anastomosing blood-filled sinuses. This and most of the other tumors are of such small size as to be found at autopsy only. A few cases have been reported of small tumors composed of tissue resembling glioma, while others consist of nerve tissue in combination with varying amounts of fibrous tissue. The nerve fibers may be medullated or non-medullated. The nervous origin of the medullary portion of the adrenal as claimed by Weisel and others, finds support in the existence of this type of tumor.

The lipomata, and cyst formations found in the adrenal are of such rarity as to be comparatively unimportant. Cysts of lymphangiomatous origin occur, which may be single or multiple but are extremely rare.

Malignant Tumors.—Much confusion exists as to the classification of these tumors, and it follows that a large variety of terms are employed by different observers in their descriptions. "Hyperplasia," "carcinoma," "adenoma," and "sarcoma" are reported, the descriptions of which often differ but slightly. More recently the term "hypernephroma of the adrenal" has been employed with increasing frequency, and at the present state of our knowledge it would seem the best term to adopt. Hypernephromata appear as single or multiple nodular growths, gray, red or yellowish in color, varying from minute bodies up to tumors the size of the fist or larger. Metastases, closely resembling the parent tumor, occur through the circulatory system and attack chiefly the lungs, liver and bones, bearing a close relation to renal hypernephroma in these particulars. The gland is usually wholly replaced by the tumor, when of clinical importance and the kidney displaced downward and upward. Microscopic examination reveals a tissue closely resembling that of the normal adrenal cortex, and practically identical with the renal hypernephroma which has already been described in detail. The cases of hypernephroma without extension into adjacent tissue or metastases appear of practically the same structure as the above; and as in the case of certain renal hypernephromata, it seems proper to class them also as potentially malignant.

Pathogenesis.—Beyond the fact that the different tumors of the adrenal as a rule arise in the portions of the gland which correspond to their histological structure, there is practically nothing known as to their mode of origin. The gliomata, and various forms of neuroma evidentally arise in the medulla, while the so-called "nodular hyperplasias" and "hypernephromata" arise in the cortical substance. It is generally believed that the zona fasciculata is the birthplace of these growths, but certain observers have held that the zona glomerulosa may be the site of origin.

The absence, in the adult at least, of adrenal tumors formed of tissues foreign to the adrenal gland is against the theory of embryological rests. In children, however, some of the reported cases have been classified as embryonic tumors, the tissues resembling sarcoma of the

embryological type. There is still too much uncertainty as regards the subject in general to dogmatize in the matter of pathogenesis.

Symptoms.—Owing to the small size of the benign, only the malignant tumors produce symptoms, the various types of growth giving rise to the same clinical picture. Without any known cause the patient undergoes a gradually progressive loss of strength and bodily wasting. Loss of weight, appetite and ambition to work are noted; nausea and vomiting, diarrhea or constipation may be present, sometimes with fever.

The presence of a *tumor* is a prominent symptom in many cases but when the enlargement is only moderate the high situation of the adrenal, covered over as it is by the lower ribs, makes the tumor impossible to detect in the earlier stages. When of sufficient size, the tumor causes pressure on adjacent structures giving rise to pain, often local, but sometimes referred to various parts of the body, as the epigastrium, shoulder or lower extremities; and when palpable, the mass usually firm, is felt below the liver and rib margin. In Vaughan's[50] case the tumor reached nearly to the pelvic brim, pushing the kidney downward and inward. *Hematuria* is a rare symptom, and was noted only twice in 67 cases by Ramsay. It is due to passive congestion resulting from pressure by the tumor on the renal vein. An occasional and important sign is the discoloration of the skin. It is not the characteristic bronzing of Addison's disease but a dirty brownish color, as a rule. Bronzing was found in only 3, brownish discoloration in 9 out of 37 cases in which the skin was altered, the majority showing only slight muddiness. The parts affected are the face, hands, genitals, axillæ, nipples and gums.

The late stages are marked by extreme emaciation and cachexia, death being preceded by convulsions or coma. In some instances the only symptoms present are wholly unrelated to the adrenal, such as edema of the glottis or respiratory disturbances: in others the patient shows a gradual decline without any local signs or symptoms.

In children the symptomatology of adrenal tumor may show certain differences from that in the adult. Infants may show a marked mental apathy and failure to develop normally; speech being sometimes defective. Skin changes, less frequent than in the adult, tend to a coppery coloration. The tumor is usually an early and marked feature, and is accompanied by pain, dyspnea and often intestinal disturbances. An important symptom is precocious puberty which has been noted in half the reported cases according to Garceau. Abundant growth of hair, especially in the genital and axillary regions, muscular and genital hypertrophy, excess of fatty tissue are commonly noted. The majority of these cases have occurred in female children, and in the earlier years of life.

Diagnosis.—Owing to the fact that the symptoms of adrenal tumor are not characteristic, but may arise from any cause of slowly progressive wasting disease, the diagnosis, in the absence of a palpable

tumor or metastatic growths, may be impossible. Even when these are present, one or both, the determination of whether the adrenal or the kidney is involved may be of great difficulty unless the skin discoloration on the one hand, or the urinary evidence of renal tumor on the other (hematuria, pyuria, or tumor cells) are present. In a child the presence of a tumor with signs of precocious puberty are unmistakable.

With regard to *renal* tumors, Israel[21] states that pain along the lumbar nerve roots occurs earlier in adrenal than in renal tumors, owing to the fact that in the former the absence of a firm limiting capsule allow local extension of the growth more rapidly. He also believes that owing to the anatomical position of the adrenal, tumors here develop more toward the median line and higher, at the costal margin, than renal.

Pararenal tumors may be impossible to distinguish from adrenal, in the absence of the signs of abnormal adrenal activity.

Addison's disease should be distinguished by the usual absence of a tumor, the presence of tuberculosis elsewhere, and the more marked pigmentation.

Tumors of the *liver* may be confused, but the characteristic outline of these growths, jaundice or evidence of a primary cause of the tumor, will often throw light on the diagnosis.

Cysts of the *pancreas,* gall-bladder, mesentery, kidney, etc., may be difficult to distinguish from an adrenal cyst, but the latter is of great rarity and the accompanying symptoms in any of the former should be suggestive.

Course and Prognosis.—Benign tumors, causing no recognizable symptoms, are of unknown duration. The course of the malignant adrenal tumor, as has been stated under Symptomatology, is usually a matter of months rather than years. From the time when the diagnosis is made, if not removed by operation, the tumor causes death in about ten months. (Garceau.[16]) In a case reported by Glomset,[17] occurring in a child aged two years, the symptoms had lasted but one month and the tumor was found inoperable.

Treatment.—The only possible chance for relief lies in the removal of the tumor, where possible, before metastases are found. Owing to adhesions to surrounding organs, especially to the diaphragm, an operation is always difficult, accompanied with danger of hemorrhage, and likely to be followed by severe shock. Where the kidney is not intimately involved in the growth, and its function has therefore been preserved, it should not be removed. The danger is obvious, in removing the healthy kidney, of the opposite kidney which has not undergone compensatory hypertrophy failing to perform the work of both, giving rise to fatal anuria. Morris[34] advises partial nephrectomy rather than removal of the whole kidney, where it cannot be entirely spared. If the kidney appears to be sound it should be left *in toto.* The results of surgical treatment are discouraging, most of the reported cases having been fatal. In the case of a cyst of the adrenal, if not removable on account of the extent and firmness of adhesions, incision, drainage and

suture into the wound is recommended. Before removal of an adrenal tumor Garceau recommends examination by palpation through an abdominal incision of the opposite adrenal, owing to the tendency of the disease to be bilateral.

ACTINOMYCOSIS OF THE KIDNEY.

Although the nature of the disease was recognized as far back as 1875, and although its occurrence in the various organs of the human subject has been frequently reported, it is only in recent years that its involvement of the kidney has been understood. The disease in the kidney is of such rarity that a detailed consideration is here unnecessary and the reader is referred for further information to the various monographs on the subject. Only certain facts bearing particularly on its presence in the kidney will be mentioned here.

Etiology.—It has been a common belief that it is especially prevalent in agricultural districts and in some way connected with the handling and particularly the ingestion of raw grain. Fraser,[15] however, is of the opinion that it is equally common in the inhabitants of cities and of the country. Another common belief was in its identity with the "lumpy jaw" of cattle. This also is disputed by modern writers. Aside from the lesions of the disease in man and animals, the sources from which the fungus has been recovered are very limited. Lord[30] reports finding the organism in smears from carious teeth, and tonsillar crypts of individuals without actinomycosis.

The precise manner in which the fungus reaches the kidney is a question which has not yet been definitely settled, but the prevailing opinion is that it is always a process secondary to actinomycosis in other parts of the body. Since the fungus enters the body by ingestion or inhalation it is the general belief that a lesion always develops at the point of entry. An infection of the tonsils or of carious teeth may easily occur without the development of a marked local lesion.

In the majority of cases of renal actinomycosis there has been a primary disease of the mouth, throat, lungs, or organs connected with the alimentary tract. Its secondary nature in the majority of cases is undisputed and this would be regarded as applying to all cases were it not for the almost unique cases of Israel[22] and Neumann,[35] in which there was no history of any primary lesion in other organs and complete recovery followed operation. This possibility, therefore, of its occurrence as a primary renal disease cannot be gainsaid.

Pathology.—In a study of the reports of 128 autopsies Garceau found undoubted actinomycosis of the kidney in 11 cases, or 8.6 per cent., doubtful primary disease in 4, and actinomycosis of the ureter (secondary to the disease in the appendix) in 1 case. The disease of the kidney arises usually by continuity from an adjacent organ, rarely by metastasis from a remote lesion (as disease of the jaw). The principal focus is usually in the liver, spleen, stomach, intestine

or appendix, and the kidney is found firmly adherent to the organ involved. It appears to resist invasion at first by thickening of the renal capsule, which forms part of the abscess wall. Finally the capsule is eroded and the parenchyma is invaded, softening takes place as the process advances in the kidney, which has thus become the seat of the abscess formation. When the renal pelvis is finally reached the pus is discharged in the urine.

FIG. 264.—Actinomycosis of kidney. (Case of Israel, from Folia Urologica.)

At first the miliary abscesses are seen scattered, especially through the cortex, singly or in groups. The areas are pale yellow, brown or green in color. The intervening areas of kidney substance are the seat of marked infiltration with leukocytes and lymphoid cells. Under the microscope the miliary abscesses are seen to contain the growing fungus with its radiating filaments, which sometimes terminate in clubbed bodies. In the wall is seen granulation-tissue formation, and in the pus is found the characteristic granules formed by the fungus itself. The glomeruli and tubules are compressed; the former may be converted

into fibrous masses by atrophy, following destruction of their capillary loops. Infarcts of the organisms are sometimes seen in the glomerular vessels.

In some cases the disease has found its way to the surface of the body, and a sinus is formed, discharging characteristic pus.

Symptoms.—The clinical picture in renal actinomycosis varies according to the presence or not of secondary infection with pyogenic organisms. When the kidney is the seat of a pure actinomycotic process the symptoms, referable to that organ, are those of a mild chronic suppurative nephritis. With a secondary pyogenic infection superadded they are those of pyelonephritis. The more serious primary disease, almost invariably present, will produce symptoms of local inflammation, abscess formation, and perhaps septicemia, which are likely to overshadow the renal symptoms, and there is nothing in the picture pointing to the kidney other than the urinary signs—pus, containing the characteristic granules.

In Israel's case there was intermittent hematuria, and sensitiveness in the kidney region was present upon exertion.

Diagnosis.—The diagnosis can seldom be made unless the organism is found in the urine, and there is pain and sensitiveness in the region of the kidney. Exploratory operation may be necessary to locate the seat of the disease.

Treatment.—Israel's case appears to be the only one on record in which nephrectomy was performed and recovery followed. This is the only possible means of cure and depends for success on the discovery of the disease when still confined to the kidney. Unfortunately, this is rarely possible. Potassium iodide may have some beneficial effect in early stages; arsenic is also recommended. The reports of vaccine therapy in this disease are too meager to warrant a conclusion as to its value.

If the disease elsewhere in the body has been checked or is easily removable, the prognosis for cure following nephrectomy is good; usually, however, the kidney involvement is late and the disease therefore incurable.

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